NAVAL POSTGRADUATE SCHOOL
Monterey, California

THESIS

AIRBORNE DECM THREAT FILE REPROGRAMMING:
ANALYSIS AND RECOMMENDATION
FOR THE BRAZILIAN AIR FORCE

by

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September, 1990

Thesis Advisor: Scott Hershey

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unclassified
SECURITY CLASSIFICATION OF THIS PAGE

REPORT DOCUMENTATION PAGE

1a. REPORT SECURITY CLASSIFICATION UNCLASSIFIED	1b. RESTRICTIVE MARKINGS
2a. SECURITY CLASSIFICATION AUTHORITY 2b. DECLASSIFICATION/DOWNGRADING SCHEDULE	3. DISTRIBUTION/AVAILABILITY OF REPORT Approved for public release; distribution is unlimited.
4 PERFORMING ORGANIZATION REPORT NUMBER(S)	5. MONITORING ORGANIZATION REPORT NUMBER(S)
6a NAME OF PERFORMING ORGANIZATION Naval Postgraduate School 6b. OFFICE SYMBOL (If applicable) 3A	7a NAME OF MONITORING ORGANIZATION Naval Postgraduate School
6c. ADDRESS (City, State, and ZIP Code) Monterey, CA 93943-5000	7b ADDRESS (City, State, and ZIP Code) Monterey, CA 93943-5000
8a NAME OF FUNDING/SPONSORING ORGANIZATION 8b OFFICE SYMBOL (If applicable)	9 PROCUREMENT INSTRUMENT IDENTIFICATION NUMBER
8c. ADDRESS (City, State and ZIP Code)	10 SOURCE OF FUNDING NUMBERS Program Element No. | Project No | Task No | Work Unit Accession Number

11 TITLE (Include Security Classification)
AIRBORNE DECM THREATFILE REPROGRAMMING, ANALYSIS AND RECOMMENDATION FOR THE BRAZILIAN AIR FORCE

12. PERSONAL AUTHOR(S) Batista, Geraldo M

13a TYPE OF REPORT	13b TIME COVERED	14 DATE OF REPORT (year, month, day)	15. PAGE COUNT
Master's Thesis	From Out/88 To Sep/90	September 90	73

16. SUPPLEMENTARY NOTATION
The views expressed in this thesis are those of the author and do not reflect the official policy or position of the Department of Defense or U.S. Government

17 COSATI CODES			18 SUBJECT TERMS (continue on reverse if necessary and identify by block number)
FIELD	GROUP	SUBGROUP	Radar Warning Receivers. User data file reprogramming process.

19. ABSTRACT (continue on reverse if necessary and identify by block number)

The objective of this work is to outline rules for the implementation of Electronic Warfare Libraries (EWRL) in the Brazilian Air Force. First, a brief description of the structure and functions of the relevant branches of Brazilian Air Force will be presented. Second, why having a reprogramming process for airborne RADAR WARNING RECEIVERS (RWR) THREAT LIBRARIES is important at the current stage of the EW development within the Brazilian Air Force. Third, based on the U.S. Navy's reprogramming process, a functional process, flow chart and responsibilities for the development and distribution of EWRL will be recommended. Finally, an execution process wil be outlined.

20 DISTRIBUTION/AVAILABILITY OF ABSTRACT ☒ UNCLASSIFIED/UNLIMITED ☐ SAME AS REPORT ☐ DTIC USERS	21 ABSTRACT SECURITY CLASSIFICATION Unclassified	
22a NAME OF RESPONSIBLE INDIVIDUAL Scott Hershey	22b. TELEPHONE (Include Area code) (408) 646-2213	22c OFFICE SYMBOL EC/Hr

DD FORM 1473, 84 MAR — 83 APR edition may be used until exhausted. All other editions are obsolete

SECURITY CLASSIFICATION OF THIS PAGE
unclassified

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Airborne DECM Threat File Reprogramming: Analysis And Recommendation For The Brazilian Air Force

by

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MASTER OF SCIENCE IN SYSTEM ENGINEERING (ELECTRONIC WARFARE)

from the

NAVAL POSTGRADUATE SCHOOL
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ABSTRACT

The objective of this work is to outline rules for the implementation of Electronic Warfare Reprogramming Libraries (EWRL) in the Brazilian Air Force (FAB).

First, a brief description of the structure and functions of the relevant branches of Brazilian Air Force will be presented. Second, why having a reprogramming process for airborne RADAR WARNING RECEIVERS (RWR) THREAT LIBRARIES is important at the current stage of EW development within the Brazilian Air Force. Third, based on the U.S. NAVY's reprogramming process, a functional process, flow chart and responsibilities for the development and distribution of EWRL will be recommended. Finally, a execution process will be outlined.

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ACKNOWLEDGMENTS

I would like to thank the Brazilian Air Force for the opportunity they gave me to take this course, to improve myself, and to know other people and their cultures.

My thanks to Mr Burton Graves, President of Phase Two Industries (PTI), who taught me about Radar Warning Receivers and gave me the book "EW Basics and ALR-67 Operation", the basis of Chapter II.

And my special thanks to LCDR Scott Hershey, my advisor, for many helpful discussions and worthwhile suggestions.

ACRONYMS AND ABBREVIATIONS

AOA	Angle of Arrival
ASPJ	Advanced Self Protection Jammer
CATRE	Training Air Command
CNO	Chief of Naval Operations
COMAR	Regional Air Command
COMAT.	Tactical Air Command
COMDA	Air Defense Command.
COMGAP	General Support Command
COMGAR	General Air Command
COMTA	Airlift Command
CONSCAN	Conical Scan
COSRO	Conical-Scan-On-Receive-Only
CPU	Central Processing Unit
CSCW	Compass Sail Clockwise
CVR	Crystal Video Receiver
CW	Continuous Wave
DECM	Deceptive Electronic Countermeasures
DEPED	Department of Research and Development
DF	Direction Finding
DIRMA	Material Directorate
ECCM	Electronic Counter-countermeasure
ECM	Electronic Countermeasures
ELINT	Electronic Intelligence
EMAER	High Staff Of Brazilian Air Force
EMFA	Brazilian Joint Chief of Staff
ERC	Emergency Reprogramming Center
ERF	Emitter Reference File
ESM	Electronic Support Measures
EW	Electronic Warfare

EWAC	EW Analysis Center
EWOPDET	EW Operational Programming Detachment
EWOPFAC	EW Operational Programming Facility
EWRL	Electronic Warfare Reprogramming Library
EWSSA	EW Software Support Activity's
FAB	Brazilian Air Force
FLTCINC	Fleet Commander-in-Chief
HARM	High-speed Antiradiation Missiles Systems
IFM	Instantaneous Frequency Measurement
LCP	Library Change Proposal
LORO	Lobe-On-Receive-Only
NERF	Naval Emitter Reference File
PEA	Electronic Applied Division
PEV	Flight Test Division
PMTC	Pacific Missile Test Center
POI	Probability of Intercept
PRF	Pulse Repetition Frequency
PRI	Pulse Repetition Interval
PRM	PRF Modulation
RF	Radio Frequency
RWR	Radar Warning Receiver
SAM	Surface-to-Air Missile
SHR	Superheterodyne receiver
SSA	Software Support Activity
SSSA	System Software Support Activity
STR	Software Trouble Report
TCV	Time Coincident Video
TD	Technical Direction
TOA	Time of Arrival
TSSC	Tactical Systems Support Center
UDF	User Data File

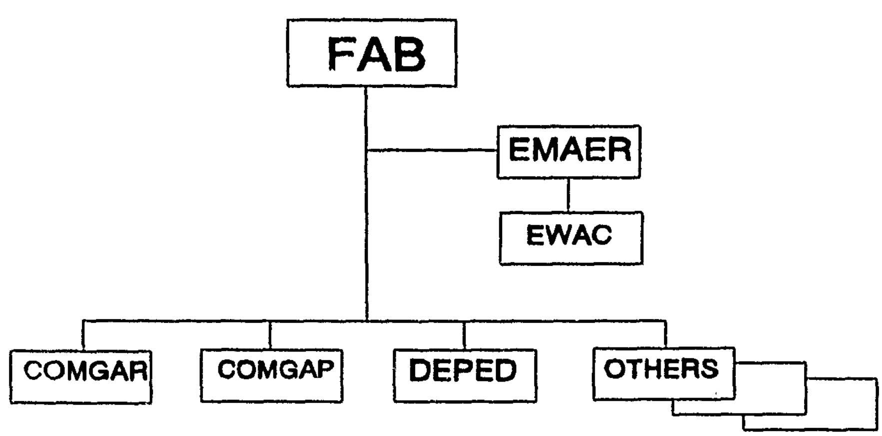
I. INTRODUCTION

A. THE BRAZILIAN AIR FORCE

The Brazilian Air Force was created in 1941 when Brazil became involved in World War II. From that time the Air Force has adapted its doctrines and organizational structure to meet the changing threat, technology and political realities as quickly as possible.

Like any military organization the Brazilian Air Force is divided into different levels of responsibility from General Commands to Operational Units.

Figure 1 presents the branches responsible for Electronic Warfare (EW) functions.



FAB	Brazilian Air Force
EMAER	High Staff of Air Force
COMGAR	General Air Command
COMGAP	General Support Command
DEPED	Department of Research and Development

Figure 1 Brazilian Air Force

1. COMGAP

This Command provides the logistic support for all aircraft and support equipment.

2. DEPED

Under this Department there are two Divisions of interest. The first is the Applied Electronic Division (PEA), where the reprogramming process is perfomed. The other is the Flight Test Division (PEV), where threat libraries are validated prior to deployment.

3. EMAER

Under the High Staff we have the Electronic Warfare Analysis Center (EWAC). This Center establishes and maintains a centralized Emitter Reference File (ERF) and will manage all reprogrammable libraries.

4. COMGAR

This Command has all the tactical and Electronic Intelligence (ELINT) aircraft. It is the final user in the process.

Obviously, the General Air Command is the most important command in an Air Force. It is presented in more detail in Figure 2. Acronym definitions follow the figure.

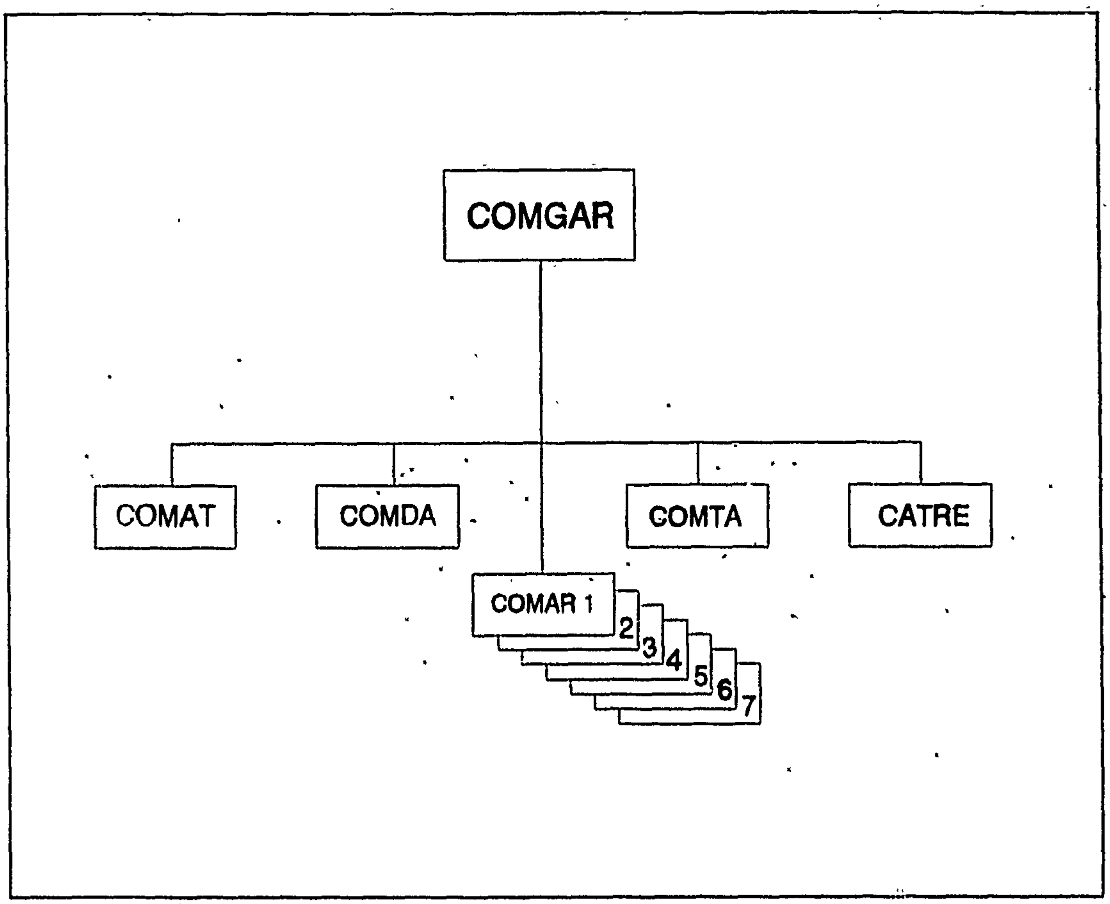


Figure 2 General Air Command

COMAT	Tactical Air Command
COMDA	Air Defense Command
COMTA	Airlift Command
CATRE	Training Air Command
COMAR	Regional Air Command

Brazil is divided in seven air zones, each of them under administration of a COMAR. The other four commands have missions common to other Air Forces.

B. EW IN THE BRAZILIAN AIR FORCE

Electronic Warfare is new to the Brazilian Air Force. Current efforts to improve doctrine and personnel training consist primarily of exercises involving specially equipped fighter aircraft that jam selected air defense system radars. These exercises test the electronic counter-countermeasure (ECCM) capabilities of the radars and provide excellent operator training. EW in the future will involve recently purchased aircraft that have RWRs with reprogrammable libraries. Establishing a reprogramming process for this new RWR is the focus of this thesis.

C. EW ORGANIZATION IN THE BRAZILIAN AIR FORCE

1. Staff Level

The EMAER directs EW Intelligence and the EW Analysis in the following areas:

EW Intelligence:

- Developing plans and doctrine
- Defining interception missions
- Allocating missions

EW Analysis:

- Determining basic parameters of intercepted signals
- Comparing intercepted parameters with those in the ERF to determine whether signals are from known or unknown sources.
- Comparing new signals with current library configurations and determine whether reprogramming is necessary.
- Distributing new signal parameter characteristics to the operational users to update local data base.

These mission areas are coordinated by the three branches in the EW Analysis Center:

- Operational Branch
- Technical Branch
- Intelligence Branch

2. Specified Commands

Each Command (under COMGAR) has an EW Cell. This EW Cell includes an EW Officer, an Electronic Officer and an Intelligence Officer. The cell plays the important role of adviser to the Commander for the integration of EW into air operations. As this integration can have both active and passive features, it requires ECM/ECCM techniques and tactics.

The EW Officer defines the operations theater where the air missions will be carried out, identifies the threat associated with the mission to the Intelligence and Technical Officers, and recommends jamming priorities to the Commander to aid in tactics development.

The Intelligence Officer and the Technical Officer work in close cooperation. The former gathers available information on the operational capabilities of the enemy air defense weapon systems. The latter studies the electronic parameters and recommends ECM/ECCM equipment employment. All collected information and new parameters are sent to the EW Analysis Center.

The General Air Command (COMGAR) directs all the EW Cells through its EW Agency. The structure and basic functions of this Agency are similar to that of the

EW Cell, but it has the additional responsibilities of overall EW Cell coordination and EW Library configuration.

3. Operational Units

Most of the Operational Units are not specialized in EW. As a result there is an intermediary link with the Operational Command for the definition of EW tasks. The Operational Unit's EW Officer has the double function of:

- Acting as a permanent link between the Operational Command and the Operational Unit.
- Directing EW training within the Operational Unit.

Figure 3 summarizes the organizational levels of EW in the Brazilian Air Force.

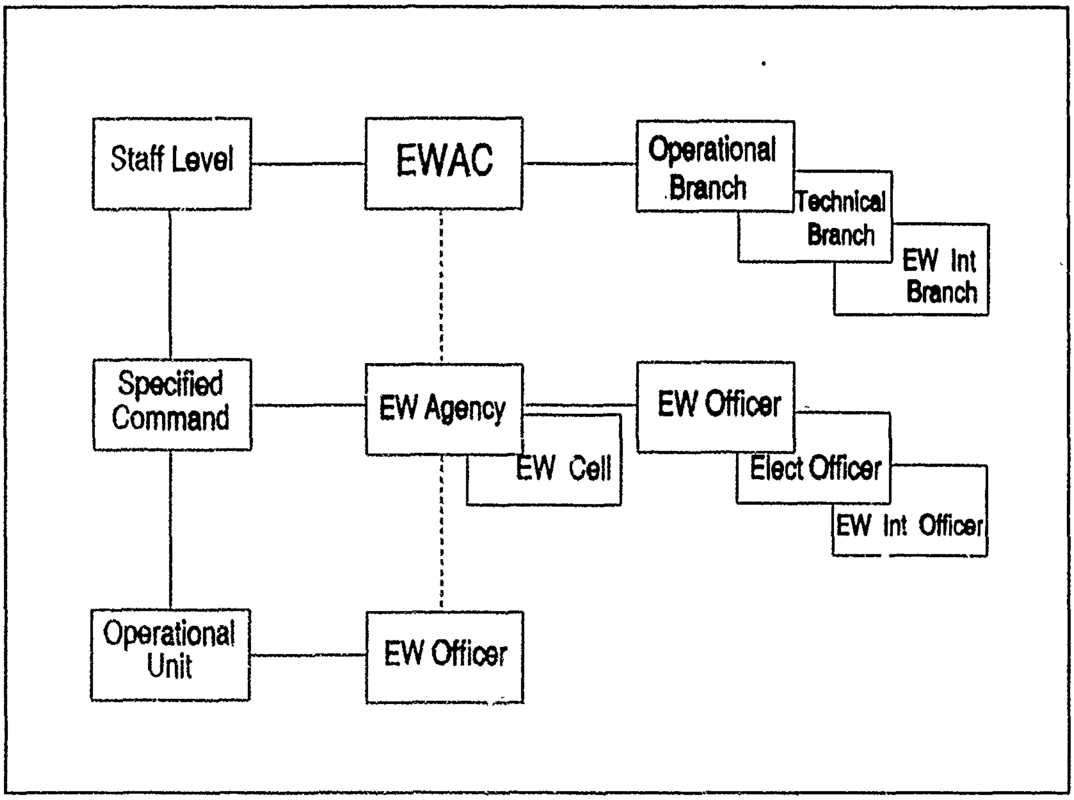


Figure 3 Organizational Levels of EW

II. RADAR WARNING RECEIVERS (RWR)

The evolution of the RWR began in the early years of the Vietnam War when the SA-2, a surface-to-air missile (SAM) used by North Vietnam, inflicted severe losses upon United States aircraft. During this period, the RWR was developed to provide pilots with the radar type and rough angle of arrival (AOA) information needed to take timely evasive or defensive action. These early systems, primitive by today's standards, could detect only a few SAMs. In spite of its limited capabilities, it proved to be a major factor in reducing the loss of US aircraft. As a result, the development of additional EW capabilities began, primarily in active countermeasures.

A. RADAR BASICS

Detecting a target using radar requires the transmission of electromagnetic energy and the receipt of resultant reflected energy from the target. Figure 4 shows a radar in its most basic form, where R is the distance between the target and the antenna, C is the speed of light (3×10^8 m/s), and t is the time between signal transmission by the radar and reception of the signal reflected back by the target.

1. Radar Equation

"The radar equation relates the range of a radar to the characteristics of the transmitter, receiver, antenna, target and environment."[Ref. 1:p. 3]

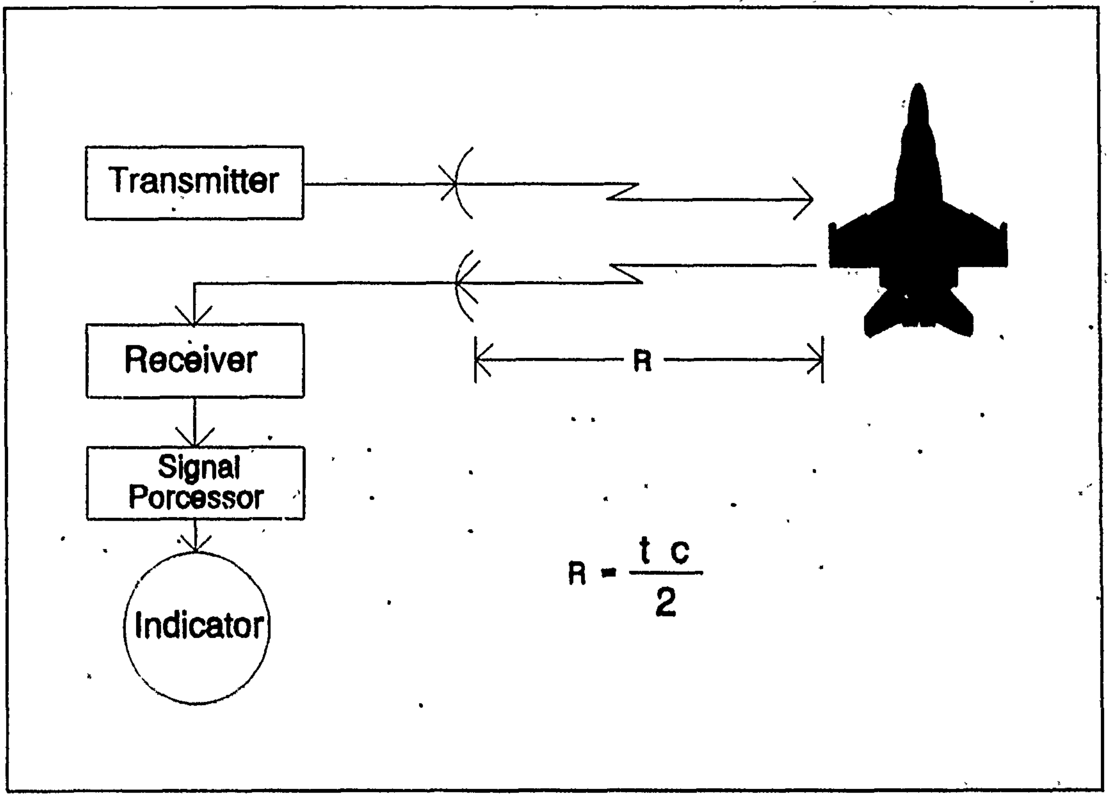


Figure 4: Basic Radar

Equation 1 shows the power density (P_d) in watts per meter squared, for an isotropic antenna (it radiates uniformly in all directions) at a distance R from the radar. P_d is equal to the transmitted power (P_t) divided by the surface area of an imaginary sphere of radius R.

$$P_d = \frac{P_t}{4\pi R^2} \qquad \text{W/m}^2 \tag{1}$$

Radars enhance their effectiveness by using directive antennas to both control and concentrate P_t. These antennas have a power gain, G, when compared with the power radiated from an isotropic antenna. Equation 2 provides the power density at a target from an antenna with gain G.

$$P_d = \frac{P_t G}{4\pi R^2} \qquad \text{W/m}^2 \tag{2}$$

As the target reradiates the received power in all directions, the power density at the receiving antenna must again be divided by the surface area $4\pi R^2$ of an imaginary sphere of radius R. The target only intercepts a portion of the incident power proportional to its radar cross section σ. Moreover, the receiving antenna captures only a portion of the echo power equal to its effective area. Calling this effective area A_e, the power received (P_r) by the radar is given by:-

$$P_r = \frac{P_t G}{4\pi R^2} \frac{\sigma}{4\pi R^2} A_e \qquad \text{W} \tag{3}$$

This is the fundamental form of the radar equation. It can be given in terms of R_{max}, when P_r is substituted by S_{min} (minimum detectable signal).

$$R_{max} = \left[\frac{P_t G A_e \sigma}{(4\pi)^2 S_{min}}\right]^{\frac{1}{4}} \qquad \text{m} \tag{4}$$

The effective area and the gain of an antenna are related by:

$$G = \frac{4\pi A_e}{\lambda^2} \Rightarrow A_e = \frac{\lambda^2 G}{4\pi} \qquad \text{m}^2 \tag{5}$$

As most radars employ the same antenna for transmission and reception, the radar equation becomes

$$P_r = \frac{P_t G^2 \lambda^2 \sigma}{(4\pi)^3 R^4} \qquad \text{W} \tag{6}$$

In this case, R_{max} is given by:

$$R_{max} = \left[\frac{P_t G^2 \lambda^2 \sigma}{(4\pi)^3 S_{min}}\right]^{\frac{1}{4}} \quad \text{m} \tag{7}$$

The power received is proportional to $1/R^4$. For a RWR, the energy must travel just one way; so, the power received is proportional to $1/R^2$. This is the first advantage for a RWR; it can detect the radar signals at a range greater than the maximum range of the radar.

a. *Noise Figure*

"Noise is an unwanted electromagnetic energy which interferes with the ability of the receiver to detect the wanted signal." [Ref. 1:p. 18]

Noise is the main factor that limits sensitivity. The radar equation, in its simplest form, does not include any kind of noise or interference. It is useful in this form for making rough calculations. However, for more accurate calculations, we must consider the atmospheric noise, the thermal noise and the propagation medium. The dominant interference is the thermal noise introduced within the receiver, N. It can be expressed in terms of Boltzmann's constant, k (1.38×10^{-23} J/°K). Equation 8 describes the internal thermal noise.

$$N = kTBF_n \tag{8}$$

Where k = Boltzmann's constant

T = system temperature, in °Kelvin

B = Bandwidth of the receiver, in Hz

F_n = Noise factor of the receiver (non-dimensional)

When the noise factor is expressed in dB it is called noise figure of the receiver, and is defined in Equation 9.

$$F_n = \frac{N_o}{kT_o B_n G_a} \tag{9}$$

The Noise Figure is the ratio of the noise of a practical receiver and the noise of an ideal receiver at standard temperature T_o (290 K). G_a is the available gain, and is defined as the ratio of the signal out S_o and the signal in S_i. The minimum detectable signal, S_{min}, in presence of internal thermal noise, is shown in Equation 10.

$$S_{min} = kT_o B_n F_n \left(\frac{S_o}{N_o}\right)_{min} \tag{10}$$

Thus, the radar equation becomes:

$$R_{max} = \left[\frac{P_t G^2 \lambda^2 \sigma}{(4\pi)^3 k T_o B_n F_n \left(\frac{S_o}{N_o}\right)_{min}}\right]^{\frac{1}{4}} \quad \text{m} \tag{11}$$

2. Pulsed and CW Radars

The continuous wave (CW) radar transmits electromagnetic waves continuously. This was the first experimental radar developed. "CW radars detect targets based on the Doppler effect (the frequency of the received wave increases from the frequency of the transmitted wave due to scattering from a moving target)." [Ref. 2:p. 401]

Therefore it can detect targets only when the range between the radar and the target is changing. Range can only be determined if the CW radar uses frequency modulation (FM) or phase modulation (PM).

On the other hand, pulsed radars are ON only part of the time. They transmit a pulse and wait for reception before the next pulse is transmitted. The space between pulses is called pulse repetition interval (PRI) and must be long enough to permit the pulse return, if reflected back from a target. The number of pulses transmitted by the radar each second is called pulse repetition frequency (PRF).

a. Unambiguous Range

If the time for a target return to be received exceeds the PRI it will be received after the transmission of the next pulse and cannot be distinguished from a target at a much shorter distance. The unambiguous range is given by:

$$R_{ua} = \frac{c(PRI)}{2} = \frac{c}{2(PRF)} \quad \text{m} \qquad (12)$$

For example, for a radar with a PRF of 600 pulses:

$R_{ua} = (3 \times 10^8) / (2 \times 600) = 250 \times 10^3$ m/s or 250 km.

b. Pulse Integration

The energy returning from a single pulse may not have enough energy to reach the minimum discernible signal (S_{min}). Integrating many pulses before attempting detection can improve the S/N level and increase detection range. Most modern radars use pulse integration.

c. *Range Resolution and Pulse Compression*

The range resolution of a radar is the minimum distance that targets can be separated radially and still be seen as separate targets. It is given by:

$$R_{res} = c\frac{\tau}{2} \qquad \text{m} \qquad (13)$$

For better range resolution the radar must have a smaller pulse width (τ). Higher values of τ increase the energy in each pulse, improving the detection range, but decreasing the range resolution.

Pulse compression is a way to improve detection range using long pulses and still maintaining the range resolution of short pulses. "Pulse compression is accomplished by employing frequency or phase modulation to widen the signal bandwidth. The received signal is processed in a matched filter that compresses the long pulse to a duration 1/B, where B is the modulated pulse-spectral bandwidth." [Ref. 1:pp 420-421]

d. *Duty Cycle*

The duty cycle of a radar is the fraction of the time that the pulses are being transmitted. Duty cycle = τ x PRF.

The relationship between duty cycle, peak power (P_p) and average power (P_{av}) is now shown.

$$P_{av} = P_p \tau PRF = P_p(dutycycle) \qquad \text{W} \qquad (14)$$

3. Search and Tracking Radars

Search or surveillance radars are the most common type of radar in military or civilian applications. They search a large volume of space and locate the position of targets giving range, azimuth and, sometimes, elevation of the target.

To determine azimuth, the radar mechanically scans the 360° by rotating the antenna at some rate. By knowing the direction that the beam was pointing when the return was received, the direction of the target can be determined. In elevation, the principle is the same. The radar can scan mechanically or electronically the space. Mechanically, the antenna moves from 0 to some elevation angle, let's say 60 degrees, and moves back again and so on. Electronically, the sweep is done by varying the beam direction without moving the antenna. This is achieved with planar phased array antennas which "are made up of individual radiating antennas, or elements, that generate a radiation pattern whose shape and direction is determined by the relative phases and amplitudes of the currents at the individual elements. By properly varying the relative phases, it is possible to steer the direction of the radiation." [Ref. 1: p. 278]

Typically, the accuracy of the measurement in azimuth or elevation is about one half of the beam width. There is a tradeoff: for better accuracy the radar employs a narrower beam and if the search volume is large, a longer time might be required to find the target.

The purpose of a tracking radar is "to measure the coordinates of a target and to provide data which may be used to determine the target path and to predict its future position." [Ref. 1: p. 152]

However, the target must first be found before it can be tracked. There are two options: the search function can be done by one radar and the tracking function by another one; or the radar can operate in search, or acquisition mode in order to find the target before switching to a tracking mode. For example, a search radar acquires an airborne target. The radar either switches to a tracking mode or hands targeting information to a separate tracking radar. The detailed course, speed and position information generated by the tracking radar is then used to program the initial flight path of a ground-to-air missile prior to launch.

4. Scan Techniques

"The antenna beam in the tracking radar is positioned in angle by a servomechanism actuated by an error signal. The various methods for generating the error signal may be classified as *sequential lobing, conical lobing, and simultaneous lobing or monopulse*." [Ref. 1:p. 152]

a. Sequential Lobing

To obtain the magnitude of the angular error, the radar switches the antenna beam between two positions (Figure 5a). Figure 5b shows the same plot in rectangular coordinates.

In this figure, the amplitude of target return at position 2 is bigger than at position 1. This difference gives the magnitude of angular error which is then used to align the switching axis with the direction of the target. When the amplitude of target return at both positions are equal, the angular error is zero, and no further corrections are needed. For two coordinates, the antenna switches the beam between four positions, one for each quadrant, given the angular error magnitude in azimuth and elevation.

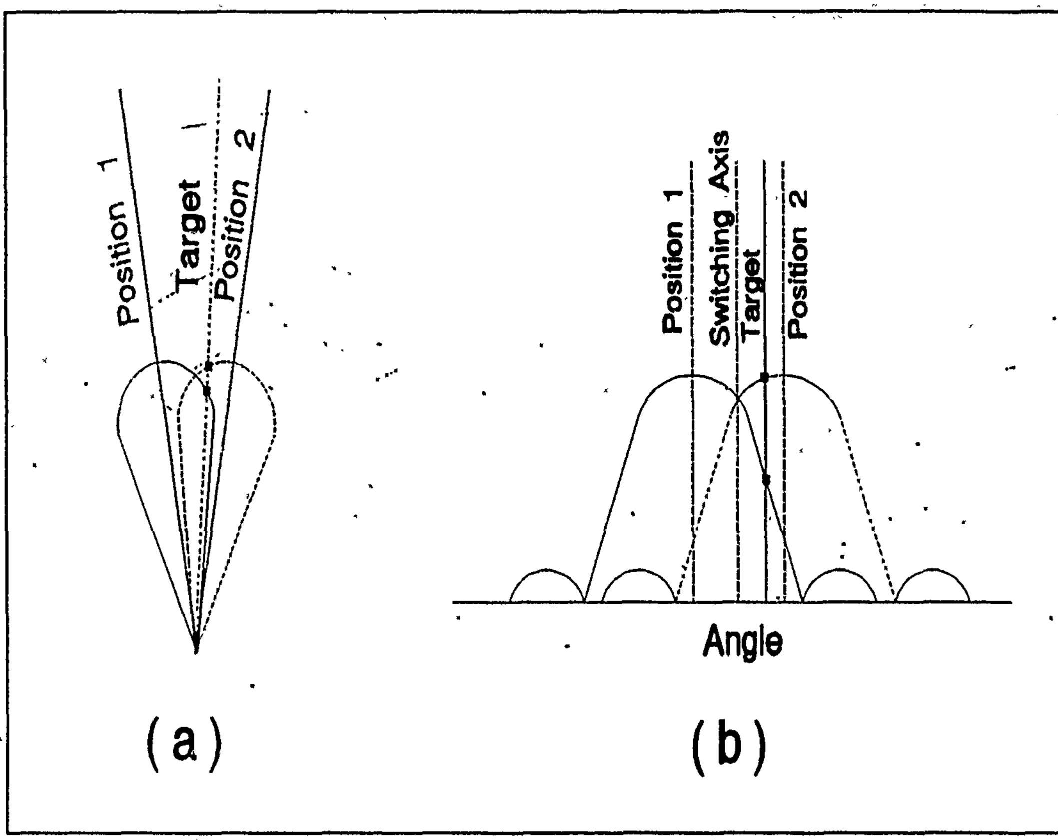


Figure 5: Lobe Switching Antenna Patterns. (a) Polar Representation
(b) Rectangular Representation

b. Conical Scan (CONSCAN)

This method is a logical extension of the sequential lobing. The antenna rotates continuously in a tight two or three degree cone, maintaining the target within this cone. By examining the amplitude of each pulse return and noting the angle associated with the difference in amplitude of the pulse returns, it gives a measure of the angular error in elevation and azimuth. This error signal is compared with the elevation and azimuth reference signals. When the angular error is zero, it means that the amplitude of all pulse returns are equal and the target is on the axis of cone direction.

"A conical-scan-on-receive-only (COSRO) tracking radar radiates nonscanning transmitted beam, but receives with a conical scanning beam to extract the angle error. The analogous operation with sequential lobing is called lobe-on-receive-only (LORO)." [Ref. 1:p. 159]

Radars using these scan methods use two antennas, one for nonscanning transmission and another for reception that scans or switches between several beams. These two methods are somewhat important because they provide the radar with the same information, but the transmitted signal is a nonscanning beam, so the target is not alerted that is being tracked.

c. *Simultaneous Lobing or Monopulse*

The methods described previously require a minimum number of pulses to provide the angular error signal. In addition, these methods can have some limitations in accuracy due to the effect of a "fluctuating echo" causing additional modulation components in the return signal. If the measurement of the angular error is made based on a single pulse, the effect of a fluctuating echo doesn't interfere with the tracking accuracy. In this method more than one antenna beam is used simultaneously. The angle of arrival (AOA) of the return signal is determined in this single pulse system by measuring the relative phase or amplitude of the return signal in each beam. Figure 6a shows two overlapping antenna patterns to obtain the angular error in one coordinate. Figure 6b and 6c shows the sum and difference of the pattern shown in (a). The sum patterns are used for transmission and both are used for reception.

The sum signal provides the range measurement and is a reference for the sign of the error signal. Signals received from the sum and difference patterns are amplified separately and combined in a phase detector to produce the error signal characteristic shown in Figure 6d. When the error signal is zero, the target is on axis.

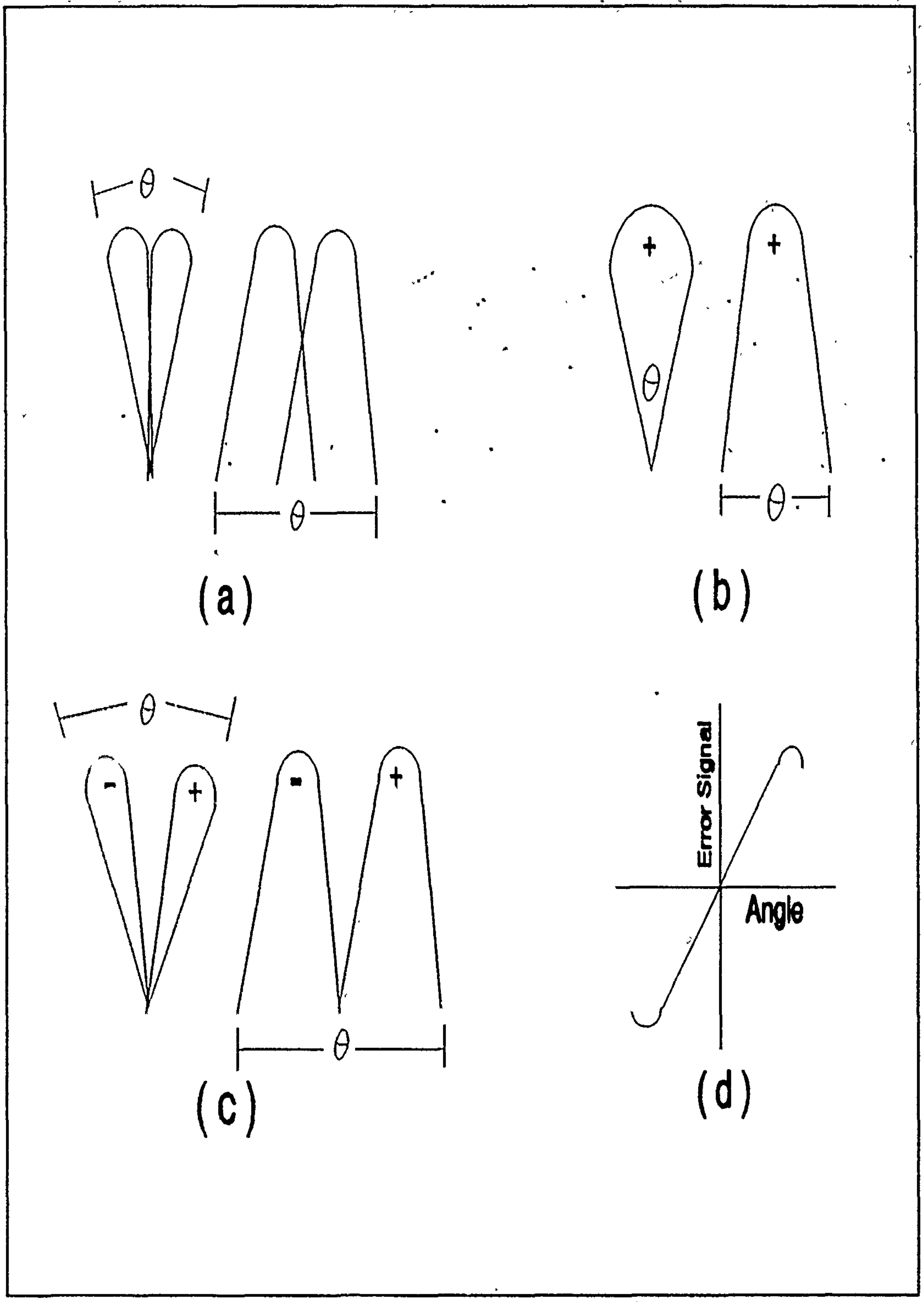


Figure 6: Monopulse Antenna Patterns and Error Signal
(a) Overlapping antenna patterns; (b) sum pattern;
(c) difference pattern; (d) product (error) signal.

B. ESM RECEIVERS

The most commonly used ESM receivers are the Crystal Video Receiver (CVR), the Superheterodyne Receiver, and the Instantaneous Frequency Measurement (IFM) receiver. Some variation of these basic types are also used. However, these receivers have a characteristic in common: their performance deteriorates in dense signal environment. To face this problem, more advanced receivers were deployed and are now in use: the Channelized Receiver, the Compressive Receiver and the Bragg-cell Receiver.

1. The Crystal Video Receiver (CVR)

The CVR is used for wideband (e.g. 2 to 18 GHz) detection of pulsed signals. "It has a multiplex that divides the band in three sub-bands, each about an octave wide. Each sub-band has a diode (crystal) detector which recovers the amplitude envelope of the transmitted pulse to produce a "video" signal (hence, "crystal video")." [Ref. 3:p. 6]

Figure 7 shows the block diagram of the CVR.

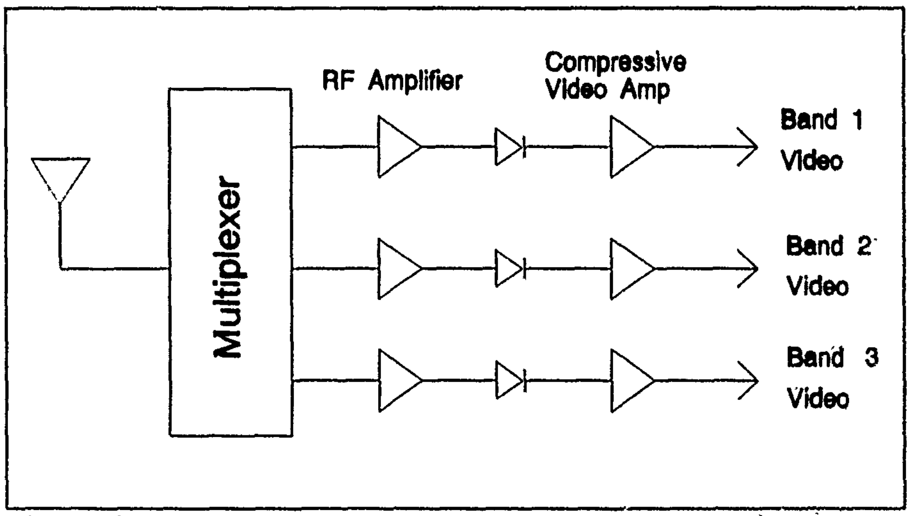


Figure 7: Crystal Video Receiver Block Diagram

Its main advantage is the simplicity of construction, small size, lightweight and low cost. However, in a dense environment, rapid degradation occurs due to amplitude distortion caused by overlapping signals in the RF bandwidth. Because of that, key threats can be masked by other signals, such as jamming or pulses from others emitters if they are coincident in time with the desired signal.

2. The Superheterodyne Receiver (SHR)

A superheterodyne receiver preselects the received frequency in a filtering section, mixes this signal with another one generated in a local oscillator to translate the received signal to a lower intermediate frequency (IF), where most of the amplification takes place. The signal is then detected and amplified to a convenient power level for driving the output display. Figure 8 shows two variations of the basic SHR. Both have the three basic sections: RF section, mixer, and IF section.

"Scanning superheterodyne receivers are typically characterized by high sensitivity, good frequency resolution, and excellent selectivity with the use of preselectors." [Ref. 4:p. 60]

They have a low false-alarm-rate[1] but they also have a low probability of intercept (POI). The POI can be improved with the use of smart scan techniques (computer controlled), when it is not necessary to scan the whole frequency range, but only for those frequency ranges where priority threats are expected.

The block diagram shown in Figure 8a is the narrowband YIG-tuned SHR. The YIG (yttrium-iron-garnet) filter acts as a preselector. Sensitivity is greater than CVR

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[1] Number of times, per unit of time, that the noise level rises above the threshold voltage and is mistaken for a real signal.

because of RF bandwidth noise reduction. Narrower bandwidth increases response time, but lowers POI.

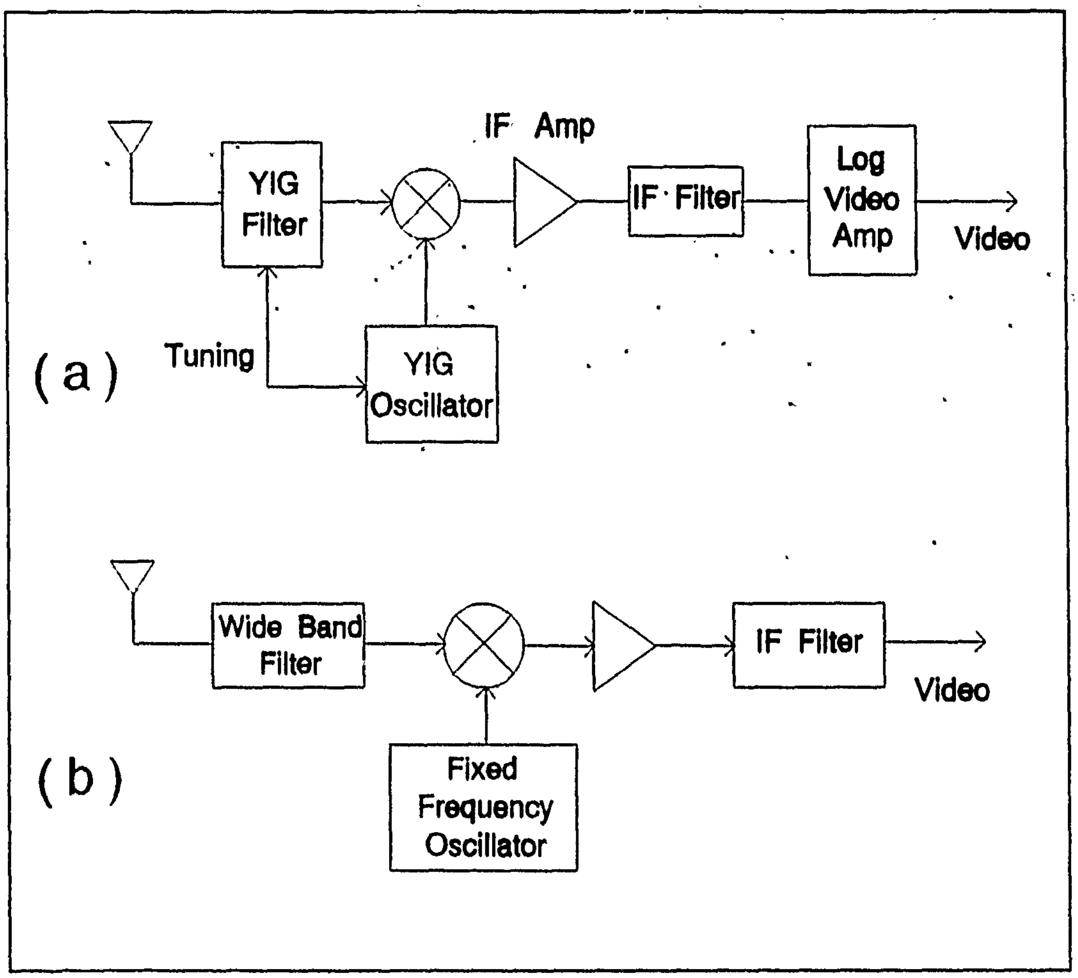

Figure 8: Superheterodyne Receiver Block Diagram

The wideband SHR, shown in Figure 8b, has higher POI, but a worse response time. A combination of both is also used. Broadband search is done with the widest bandwidth, while finer resolution tasks are performed with narrower bandwidths. This approach improves the response speed without degradation of the POI.

3. The Instantaneous Frequency Measurement (IFM) Receiver

"The IFM receiver is the simplest, most mature technique for obtaining pulse-by-pulse frequency information over a broad band frequency band." [Ref. 4:p. 64]

Accurate frequency information is useful in a variety of purposes, such as deinterleaving multiple emitters in a dense environment and the detection and display of frequency-agile and pulse-compression radar emitters. Figure 9 shows its block diagram.

The IFM receiver can scan over a wide bandwidth and give accurate frequency information on most emitters. Its POI is near 100%. The main limitation of the IFM

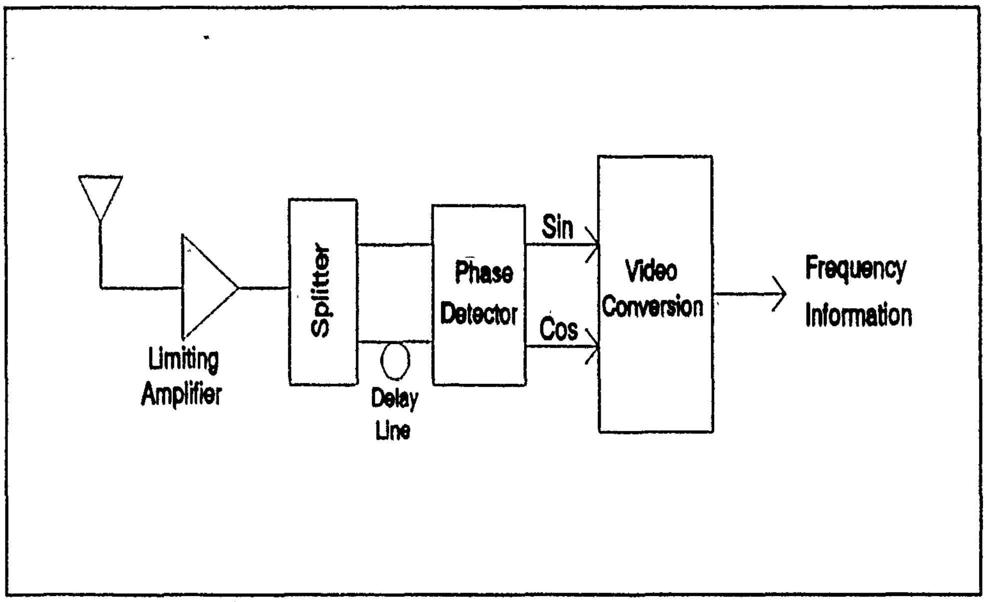

Figure 9: IFM Receiver Block Diagram

receiver is that it can respond to only one signal at a time. If two signals occr simultaneously, the strongest signal will be measured, masking the weakest one. If two signals are received, close in power level, the resulting information may be an average of the two frequencies.

4. Advanced Receivers [Ref. 5]

All the receivers previously described have one characteristic in common: their performance deteriorates in a dense signal environment. The Channelized Receiver, Compressive or Microscan Receiver and the Bragg-cell or Acousto-optic Receiver were developed to increase performance in today's dense signal environment.

a. Channelized Receiver

The channelized receiver has a bank of filters that subdivide the RF spectrum. Each channel has a separate detector to cover one portion of the spectrum. This construction allows instantaneous coverage of a wideband with high frequency resolution. It is sometimes called a contiguous filter receiver.

b. Compressive Receiver

It is a special type of SHR in which the RF bandwidth being covered is scanned in a time typically less than the duration of pulses to be intercepted. The frequency scanning in this receiver produces RF output pulses whose position in time are related to the frequency of input signals. Thus, frequency is determined on a pulse-by-pulse basis. The technique used involves time compression of received pulses. The compressive receiver is also called a microscan or microsweep receiver.

c. Bragg-cell Receiver

This receiver uses the Bragg-cell signal processing technique. A Bragg-cell is a device which converts an RF signal into a acoustic wave of the same frequency, and which, when probed by a monochromatic light beam, deflects the light beam at a angle proportional to frequency. Thus, the frequency of threat emitter can be determined with high accuracy.

C. DIRECTION FINDING

In EW, when a signal is intercepted, it is usually important not only to identify the source of the signal and to extract information from it, but also to know the angle of arrival (AOA). There are several receivers that can determine signal AOA, ranging from the old goniometer, that uses loop antennas, to modern receivers that use time-difference-of-arrival, phase measurement, Doppler effect, etc.

For the purposes of RWRs, the AOA is an important signal discrimination factor. There are two primary techniques used for direction finding: amplitude-comparison method and the phase-comparison or interferometer method. "Virtually all currently deployed RWRs use amplitude-comparison direction finding (DF)." [Ref. 4:p. 99]

A basic amplitude-comparison system can determine AOA or bearing with the use of two independent receiver channels and equally spaced antennas to provide a 360 degrees of coverage. Knowing the direction of the antennas and measuring the amplitude of the signal in each channel, a ratio is obtained by subtraction of the logarithmic amplitude. The bearing can be computed from the value of this ratio. However, typical systems use four or six antenna elements and receiving channels to prevent ambiguities in determining the direction of the signal. "In general, typical accuracies can be expected to range from 3 to 10 degrees rms for multi-octave frequency band amplitude-comparison systems which cover 360 degrees with four to six antennas."[Ref. 4:p. 100]

Phase-comparison or phase interferometer DF systems are utilized when very accurate AOA information is required (usually accuracies from 0.1 to 1 degree and with no ambiguities over ± 90 degrees). They will not be discussed here.

D. RADAR DIRECTED MISSILES

There are basically two ways to direct missiles using radar principles: command guidance and terminal homing.

With command guidance, the radar transmits control signals to the missile to direct it to intercept the target. Figure 10 shows the elements involved in command guidance. In this case the radar must track the target as well the missile to make the interception. But the missile is small in diameter and presents the radar with a relatively small cross section. As a result, the missile can stray outside the tracking beam of the guidance radar. To solve this problem, the missile contains a transponder that replies to a guidance signal from the radar. Using this system, the radar can easily guide the missile toward the target. The signal transmitted by the radar is called a beacon and the signal transmitted back by the missile is called a downlink.

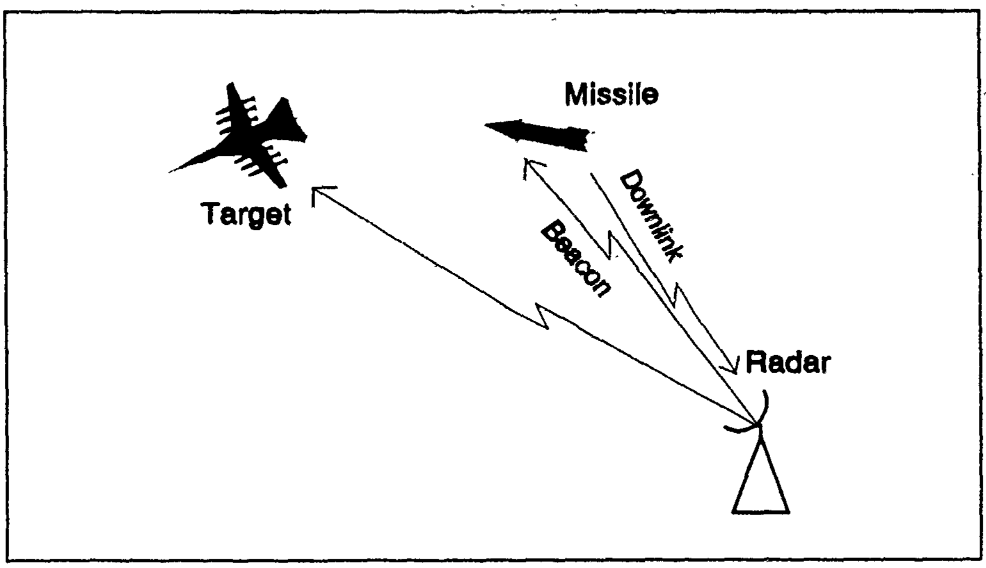

Figure 10: Command Guidance Missile

Terminal homing missiles control their own flight path. To perform the flight path calculation the missile must know the location of the target. The radar, in this case, provides an illumination source which reflects off the target. The missile contains a receiver that locks onto this reflection and uses it as a homing source. This signal is typically continuous wave (CW). Figure 11 shows the terminal homing configuration.

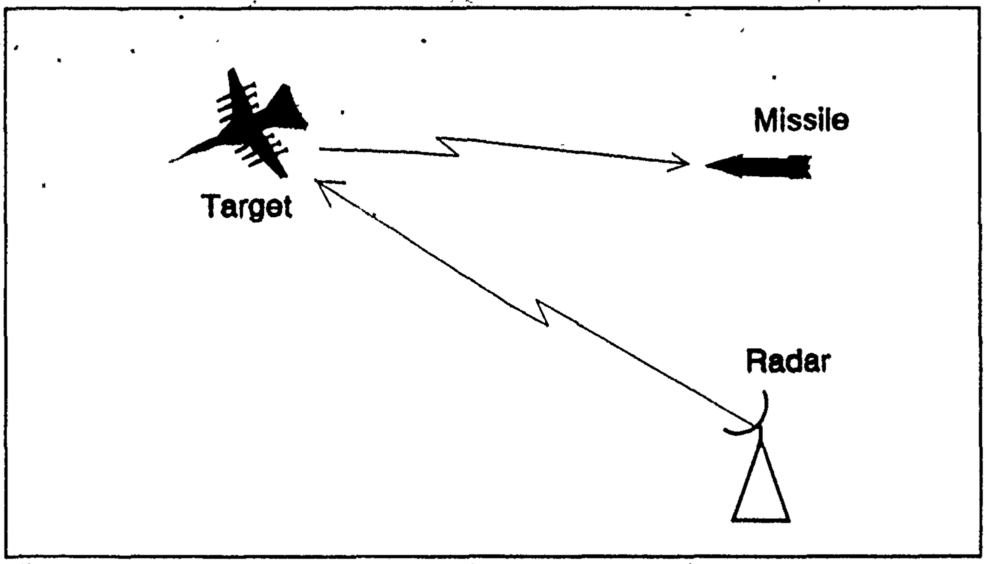

Figure 11: Terminal Homing Missile

E. RADAR WARNING RECEIVERS (RWR)

"The primary function of a RWR is to warn the crew of an immediate threat with enough information to determine a course of evasive action." [Ref. 4:p. 47]

To do its function, the RWR intercepts the radiation of an enemy radar, stores intercepted radar pulses and analyses its parameters (frequency, TOA, PRI, AOA, amplitude, pulse width, etc). Based on the parameters, it sorts the pulses into groups associated with a particular radar emitter and then compares this data with known radar parametric sets stored in the threat library. If there is a match between received data and stored data, the radar can be identified and the pilot will be informed. The action the pilot takes in response to the RWR information will depend on the lethality of the threat signal received as identified by priority settings in the threat library. A basic diagram of an early RWR, used in late 1960's, is shown in Figure 12. It consists of four broadband crystal video receivers, a low band receiver covering portions of the C/D band (.5 to 2 GHz), a processor, an azimuth indicator,and a control unit.

But soon (early 1970's) the detection capability of this type of RWR became degraded with the advent of new threats (like monopulse radars), the use of PRF modulation (PRM), dense environments, and the introduction of terminal homing missiles using CW signals for tracking the target. These signals cannot be detected with crystals video receivers. Worse yet, this class of signals tends to desensitize the crystal video receiver to the pulse signals which it is designed to detect. The inability of this RWR to properly respond to these new threats provided the motivation for the development of new systems.

A new generation of RWR was developed to face the diverse set of new threats described above. RF amplification was provided in all receiver channels to increase the system sensitivity in all aspects. To detect and measure CW signals, a superheterodyne receiver was added. In addition to providing a CW capability, it provides the means to measure the RF frequency of pulse signals and to provide an additional parameter for identification, when required. A direction finding (DF) capability was added to C/D band, and the frequency range of this receiver was increased to monitor the entire band. The DF capability was needed because several of the threats employ optical tracking to avoid

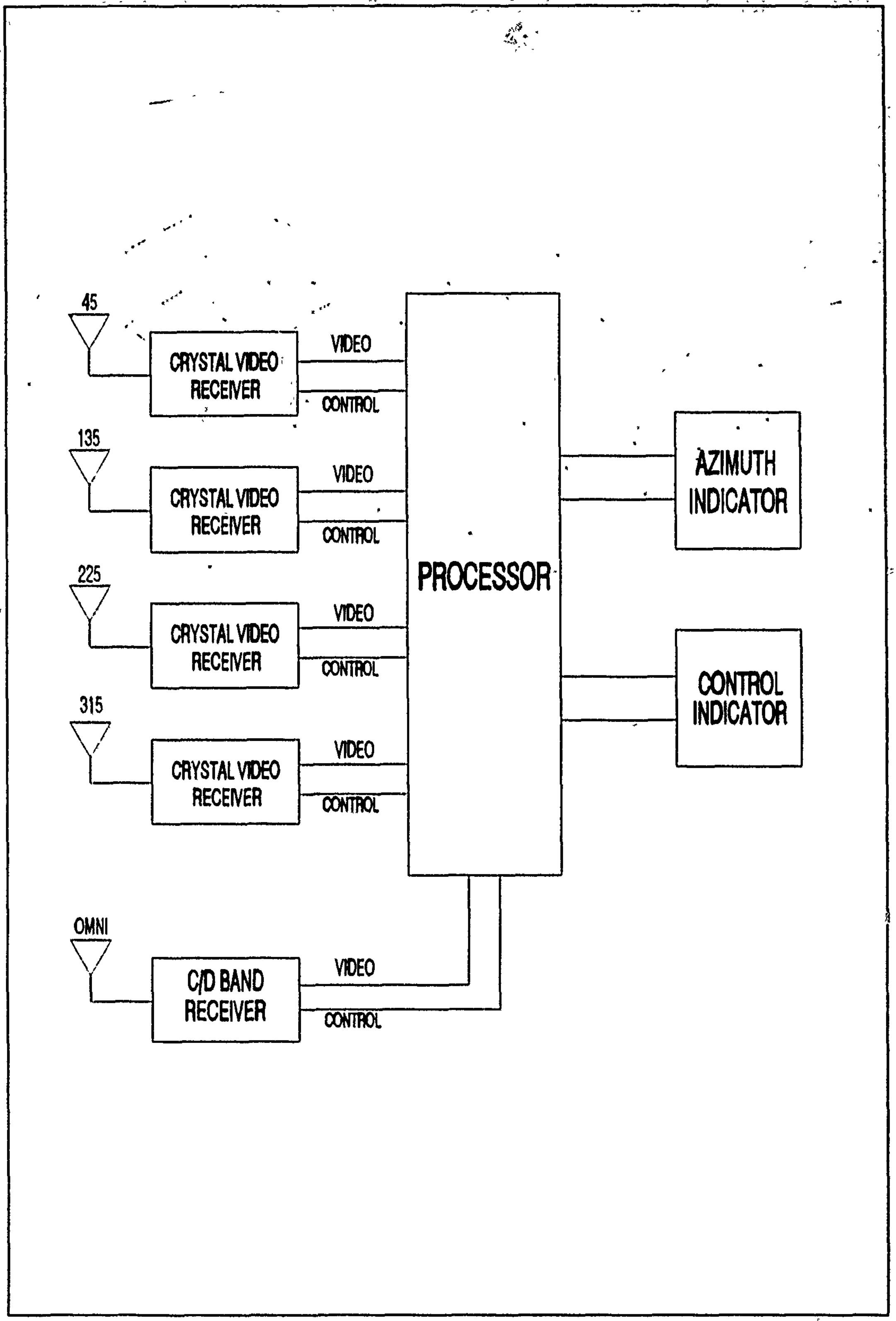

Figure 12: RWR Block Diagram

detection; thus, the guidance signal (in the C/D band) was the only emission and knowing its direction was essential. Another major improvement provided by this new generation of RWR is its ability to operate cooperatively with the ECM systems.

Figure 13 shows the block diagram for the ALR-67, that fulfills the specifications given above. A brief description follows.

The four quadrant receivers cover the 2 to 8 GHz band and are fed from four directional cavity antennas. These antennas are oriented in order to provide a full 360 degrees of coverage.

"Each quadrant receiver operates on a single 4 GHz sub-band and provide two outputs: an RF signal, which has been downconverted to the 2 to 6 GHz band, and a detected video signal, which is representative of the ampli-tude envelope of the RF signal. The RF signals go to the superheterodyne receiver and the video signals go to the processor. A master oscillator in the superheterodyne receiver provides a local oscillator (L.O.) signal to each of the quadrant receivers, so that each of the four downconversions, or frequency translation processes, are performed identically." [Ref. 3:p.12]

"The integrated low band antenna is a combined antenna array and receiver channel which covers 0.5 to 2 GHz (C/D band). The antenna array consists of five omnidirectional vertical stubs. Four of these are combined at different phase angles to produce four outputs that are representative of angle of arrival. These four signals are then amplified, detected, and routed to the processor in the same manner as the video signals from the quadrant receivers. The fifth antenna is routed directly to the superheterodyne receiver." [Ref. 3:p.12]

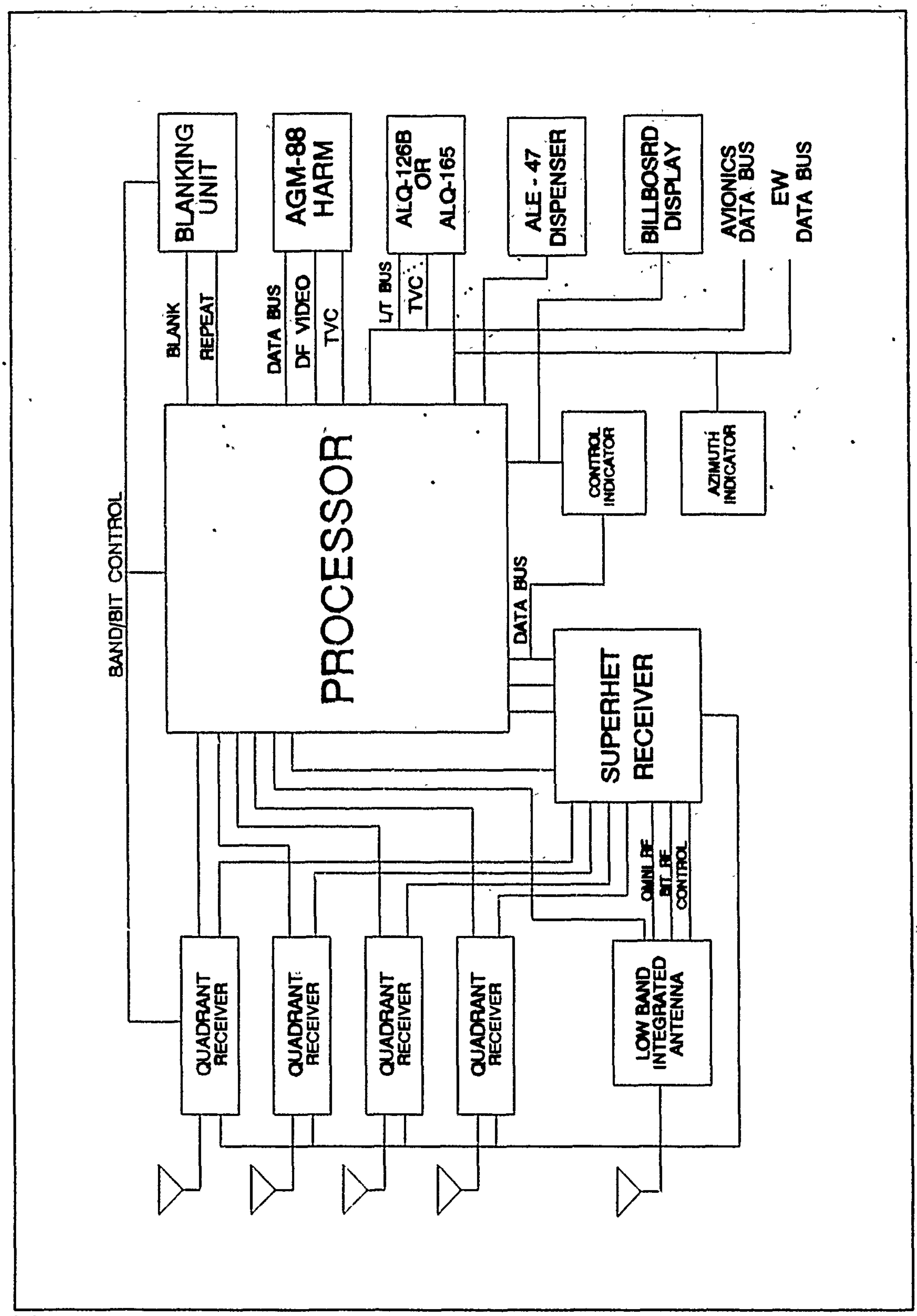

Figure 13: ALR-67 Block Diagram

The primary function of the SHR is to receive CW signals and determine their direction-of-arrival; but, it is also used to measure the frequency of pulse signals.

The SHR is controlled by the processor, which commands it via a serial data bus. The SHR contains a controller of limited capability which allows it to perform some of its functions autonomously.

The processor is the central computing element of the ALR-67 system. It contains two data buses: a remote terminal on the avionics data bus and a bus controller on the EW data bus.

"The EW data bus is used to drive the azimuth indicator as well as communicate with the ECM system (ALQ-126B or ALQ-165). In addition to the data bus interface, there are real-time links between the ALR-67 and these systems: six time coincident video (TCV) gates and a lookthrough (L/T) bus. The TCV lines provide the ECM with timing cues to trigger a jamming response to certain pulsed radar threats." [Ref. 3: p. 13]

The L/T bus instructs the ECM system on how to modify, reduce or cease its transmissions when the ALR-67 collects its needed data (if the ECM system is using deception techniques that result in transmissions which mask the threat pulse).

The other avionics interfaces include the AGM-88 HARM (High-speed Anti Radiation Missile) and the ALE-47 dispenser. The ALE-47 dispenser interface is implemented in hardware, but, to date, no software exists.

"Finally, the ALR-67 has a control and azimuth indicator which provides the pilot with an overview of the threat situation. The control indicator provides options over the display, primarily, signal prioritization and format. The audio cues that the processor inputs to the intercom can also be controlled by this unit." [Ref. 3: p.15]

1. Processor

The processor is the central computing element of any RWR. In the case of the ALR-67, it contains two computers, designated ATAC-16M. They are both 16 bit CPUs (central processing unit) and each contains 16 general purpose registers. Each CPU has a private program memory while the data memory is shared. A block diagram is shown in Figure 14.

The physical description of each component and how they perform calculations to give the necessary information will not be done here. The focus will be on the identification process.

Once signals are received, they are sorted by angle. At this point, the software applies an array of time-of-arrival (TOA) based sorting algorithms to separate the pulses into individual signals.

"A master track file is created and maintained in CPU 1, which summarizes the characteristics of each signal. Once a track file entry has been made, the parameters of that signal are compared to the emitter library (User Data File - UDF) to determine the threat type. If a match is made, it is entered into the file together with its priority. Frequently, a match cannot be made, and an additional parameter, such as frequency, may be required. If so, the highest priority threat that this signal might be is temporarily entered into the track file, and the frequency measurement request is placed onto the SHR task queue. Later, when the measurement is completed, the file is updated and the entry is again compared to the library for a refinement of the identification."[Ref. 3: pp. 30,32]

Concurrent with the broadband pulse collections, the SHR is detecting and analyzing CW signals. Data from the SHR is digitized and entered into the other CPU.

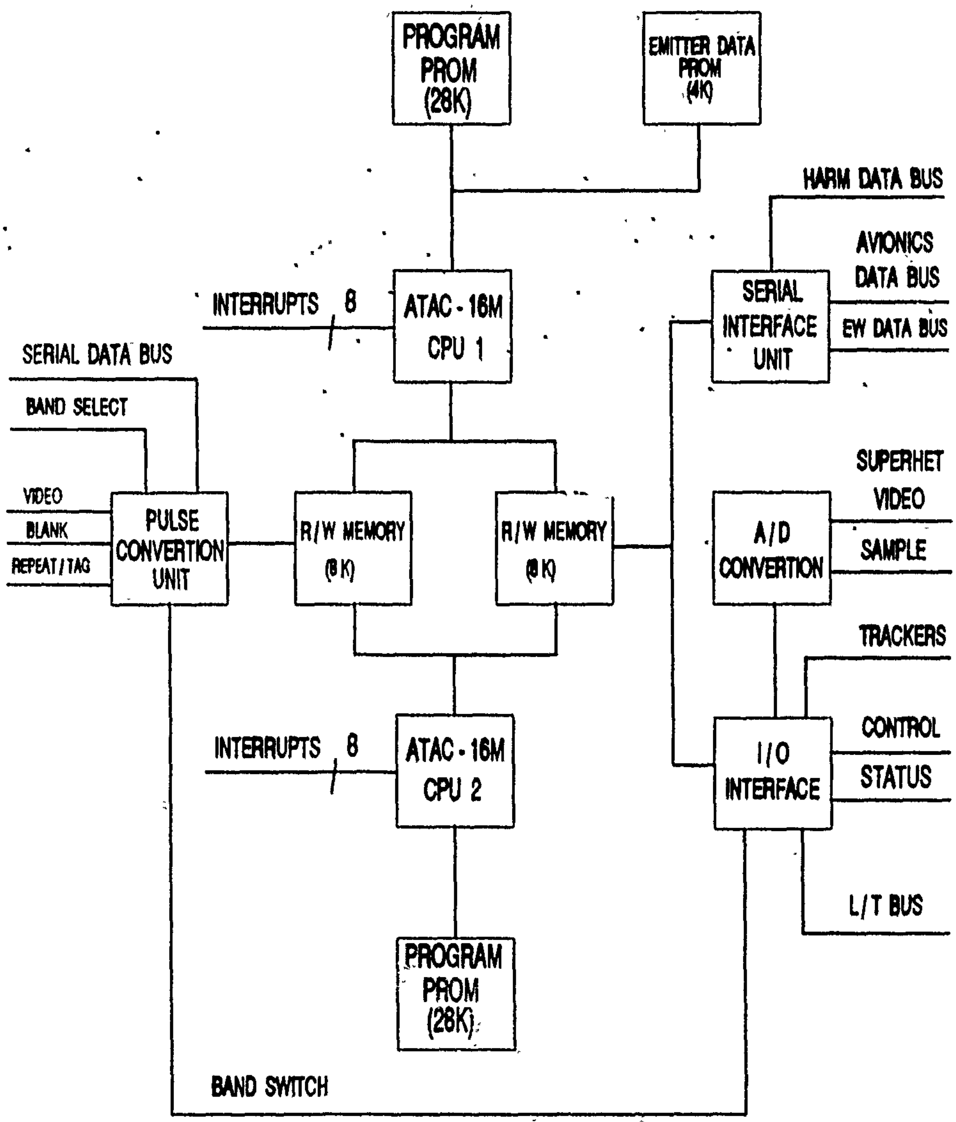

Figure 14: ALR-67 Processor (CP-1293)

CPU 2 analyzes this data and places the results in the track file. The SHR data port in this memory is shared with the tracker hardware and the data bus hardware. The tracker hardware consists of a set of latches which are continuously compared to the master clock. When a match occurs, a TCV gate and an interrupt to CPU 2 are generated. The computer then loads a new time for that gate to be generated. Periodically, updates are required to resyncronize the gate to the received signal. When an update is required, the tracker hardware causes the quadrant receiver (if the signal is in high band) to switch to the band in which the signal is located for a 5 microsecond interval. Any pulses digitized during that time will receive a tracker tag in order to identify them. After a specified number of pulses from a signal have been received, the update logic is disabled and the tracker returns to its mode of operation. At the same time, the tracker update software is enabled which compares the TOA of the received pulse with the center of the TCV window and makes adjustments, as necessary.

"The data bus hardware contains its own processor which communicates with CPU 2 via the shared data memory. Outgoing messages are stored in convenient locations at the message generating software. A control word is placed in a dedicated location and an interrupt to the data bus hardware is generated. This hardware then examines the control word and transmits the message in accordance with the command. In the case of incoming messages a similar operation occurs. The software, which is expecting the message, defines the storage area and sets control words in dedicated locations defining the actions to be taken." [Ref. 3: pp. 32,33]

2. Software

"The software of the ALR-67 system is organized into a set of seventeen modules, a common data area, and a user data file (UDF), which contains the classified threat parameters. The modules and the common data base area are divided into blocks. Each of the module blocks and the UDF are allocated to one of the two CPUs within the processor." [Ref. 3: p.38]

The common data base is located in RAM memory and is accessible by both CPUs. It contains all tables, flags, and variables used by the software. The User Data File (UDF) resides in CPU 1. It contains the classified parameters of the threat signals to be detected and identified.

A brief description of each of the seventeen modules and the CPU in which it resides follows:

Residing in CPU 1 and CPU 2:

- Executive: Interrupt and timing control for all modules. Maintain module status, allocate CPU time on priority basis. Process and schedule subroutine requests.
- Built-in-test: Test system integrity in background mode. Call for processing and analysis of test signals. Provide for diagnostic test of system.
- Data Bus Management: Control transmission and receipt of messages over three serial data buses.
- Superheterodyne: Control and schedule superheterodyne receiver.
- Test and Evaluation (T&E): Dump data to flight recorder.

Residing in CPU 1:

- Receiver Control: Control and schedule wideband receivers.
- Preprocess: Provide data screening and sorting. Construct data linked lists.

- Wideband Processing: Control analysis of wideband pulse data. Locate and depopulate pulse trains. Construct and update a track list of emitters.

- Emitter Manager: Identify signals in track list. Select signals to be displayed. Correlate guidance beacons with target tracking radars. Manage data for trackers, HARM, ALQ-126B.

Residing in CPU 2:

- Guidance Analysis: Determine missile activity (MA) or missile launching (ML) status of guidance signals.

- Tracker Control: Provide tracker controlled video handoffs to ALQ-126B, HARM, ASPJ.

- Display: Provide codes and coordinates for symbol display. Separate overlapping symbols, provide smoothing. Monitor switch settings, control lights and tones.

- Harm Interface: Control interface between ALR-67 and HARM.

- ALQ-126B: Control interface between ALR-67 and ALQ-126B.

- ASPJ: Control interface between ALR-67 and ALQ-165 ASPJ.

- Mission Computer Interface: Control interface between ALR-67 and mission computer.

- CSCW (APR-43): Process data from compass sail clockwise (CSCW). Construct and update track list of emitters.

F. SUMMARY

Modern Radar Warning Receivers are usually one subsystem of an EW suite of subsystems designed to identify the threat, take active electronic countermeasures, and, in some cases, launch an anti-radiation missile at the threat emitter. The functional integration of these subsystems is crucial to aircraft mission success.

Radar Warning Systems must not mistakenly identify a harmless or friendly signal as lethal or vice-versa. An accurate and updated threat library is essential to the mission success. Unfortunately, some modern EW suites contain a separate library for each subsystem (RWR, jammer and missile). This complicates both the suite integration and threat library maintenance functions.

From these considerations we can see the importance of having an current and accurate library. Although the range of data stored in the libraries allow some flexibility, degradations or modifications of these data, even in peace-time, will require frequent updates.

Imagine now, in a war-time scenario, when the enemy intentionally changes the emitter parameters to avoid detection and, thereby, increase their effectiveness. If these new parameters are outside the parametric value ranges of the corresponding threat description in the libraries, the system either does not recognize the emitter or misidentifies it. Neither of these alternatives is operationally acceptable. Reprogramming, then, must be accomplished in order to ensure proper response to a threat.

III. THE U.S. NAVY REPROGRAMMING PROCESS

This chapter is based on OPNAVINST C3430.23A which issues responsibilities and procedures for defining, developing, maintaining, managing and distributing tactical Electronic Warfare Reprogrammable Libraries (EWRL) for automated non-communication EW systems.

The goal of the EWRL Support Program is standardized and predictable identification/responses in all EW reprogrammable systems.

The Naval Emitter Reference File (NERF) has been established as the common reference source for support program library information. The EW Operational Programming Facility (EWOPFAC) provides routine administration of the EWRL program and maintains the NERF. The NERF utilizes data from various intelligence sources and is maintained specifically for the EWRL Support Program. It contains friendly, non-hostile and threat parameters, platform data, general order of battle and theater specific parametrics.

The EW Operational Programming Detachments (EWOPDETs), reporting to the Fleet Commander-in-Chiefs (FLTCINCs), develop formatted EW libraries for each reprogrammable system. These libraries are forwarded to the appropriate Tactical Systems Support Center/Software Support Activity (TSSC/SSA) where they are coded, tested for proper responses, and distributed to Fleet users.

During EW system development, EW library structure is the responsibility of the cognizant systems command or developing agency, but early integration with the EWRL

Support Program is required. Developmental library data used for software testing shall be drawn from the NERF.

Figure 15 lists the EWRL participants.

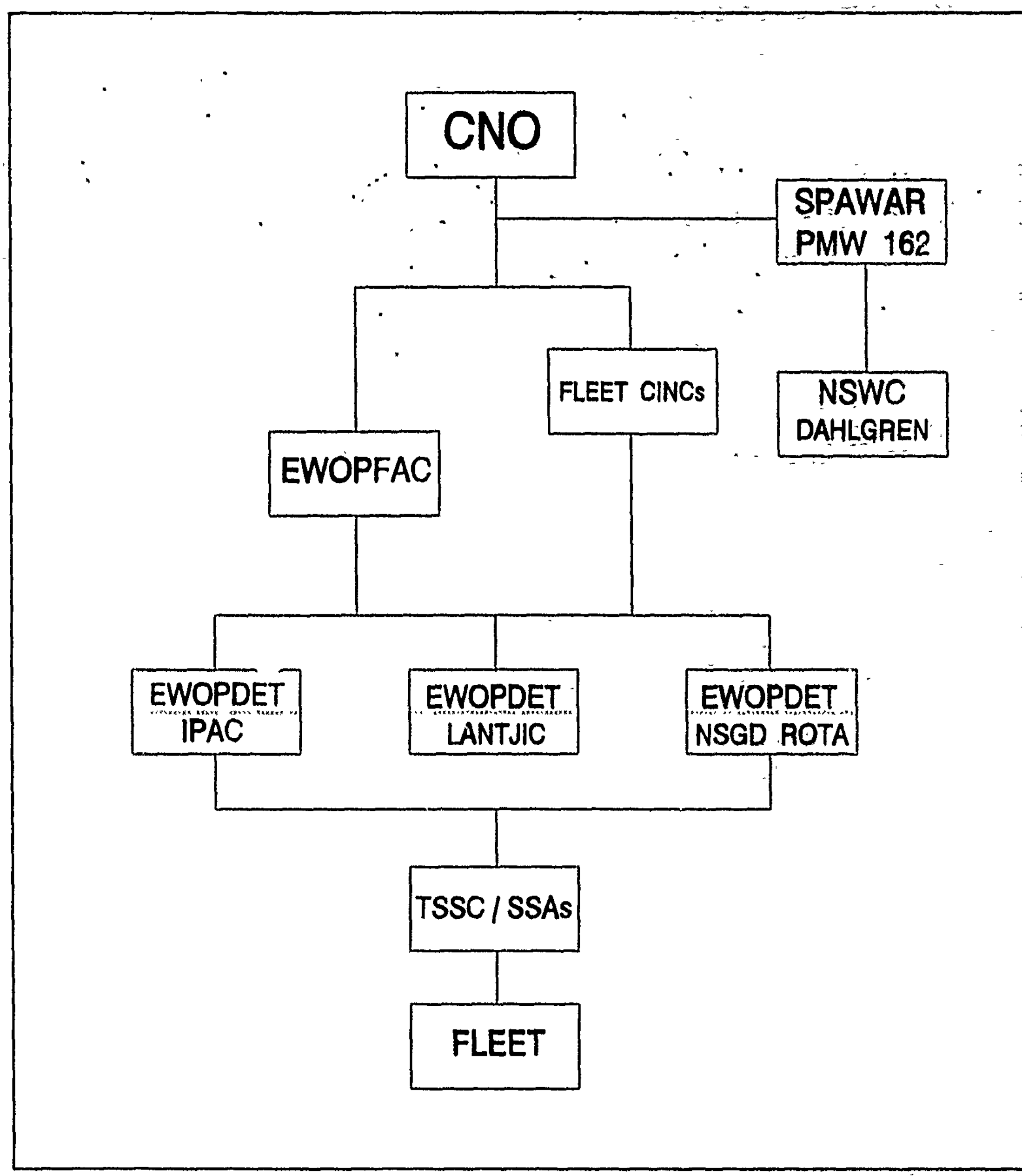

Figure 15: EWRL Participants

A. ACTION

Fleet Commander-in-Chief will initiate the request for a new or updated library or endorse a change request from a subordinated command.

FLTCINCs, with assistance from their supporting EWOPDET, will select and prioritize a list of emitters to be included in the update. Once compiled, this list is then submitted to the appropriated Theater Electronic Intelligence (ELINT) Center.

The ELINT Center will then coordinate with the local EWOPDET to supplement the list with formatted EW library parameters from the theater emitter data base. This list is then forwarded to the cognizant TSSC/SSA.

The TSSC/SSA will convert the formatted parameters into a tactical EW library that conforms to the hardware requirements of the EW system(s) for which it is intended. The TSSC/SSA will then test and validate each element of the library to ensure its accuracy and proper integration with other platform systems.

When directed, a certified copy of the tactical EW library will be distributed to fleet units by the TSSC/SSA based on procedures and schedules that have been coordinated between the TSSC/SSA, Commander, Naval Air Systems Command (COMNAVAIRSYSCOM), the appropriated Type Commander and the FLTCINC. For a more detailed explanation refer to OPNAVINST C3430.23A, in Appendix.

Figure 16 shows the EWRL Support System.

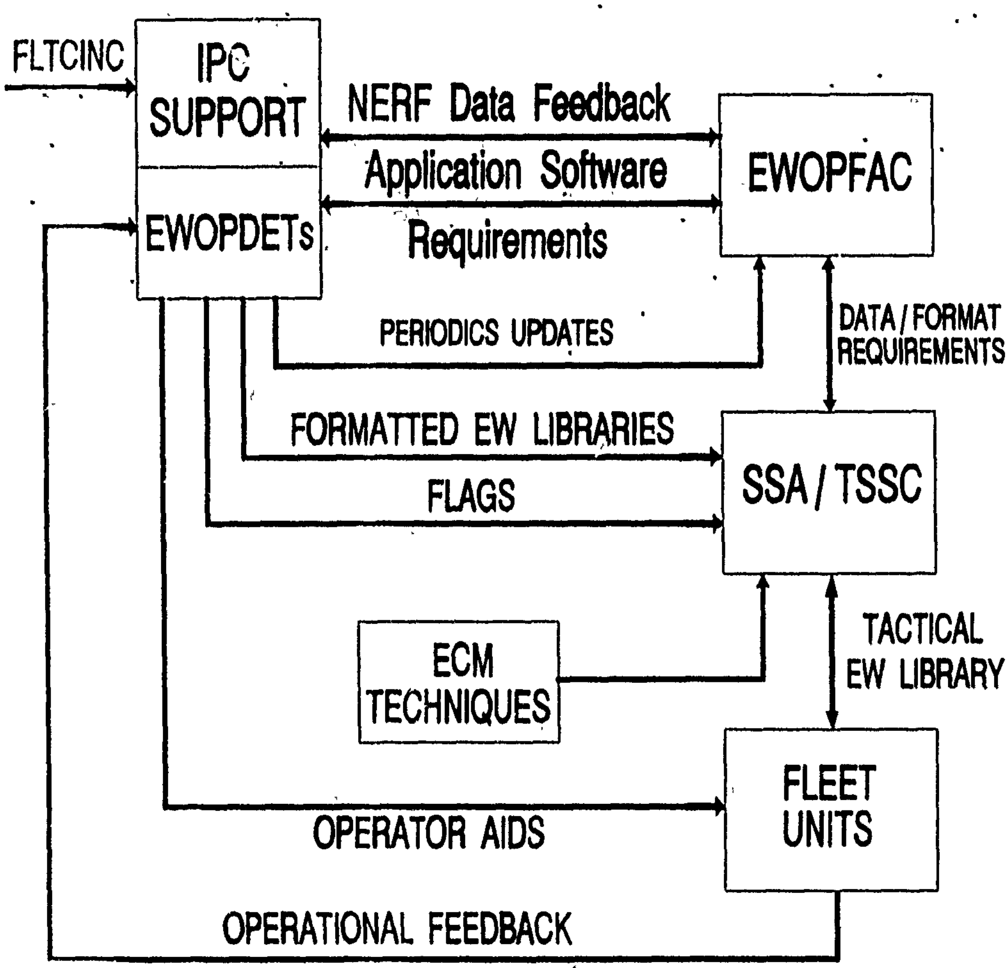

Figure 16: EWRL Support System

IV. THE BRAZILIAN AIR FORCE REPROGRAMMING PROCESS

This chapter will focus on the functional process organization, flow chart and responsibilities for the development and distribution of Brazilian tactical EWRL. The physical process of changing RWR libraries will not be discussed because the system's manufacturer will provide the technical support needed to reprogram the library. The difficulties, initially, are not technical, but philosophical, doctrinaire and organizational.

The responsibilities and procedures for EWRL in the U.S. Navy, as outlined in Chapter III, will be adapted to the organizational structure of the Brazilian Air Force.

Figure 17 shows the organizational structure for EW in the Brazilian Air Force.

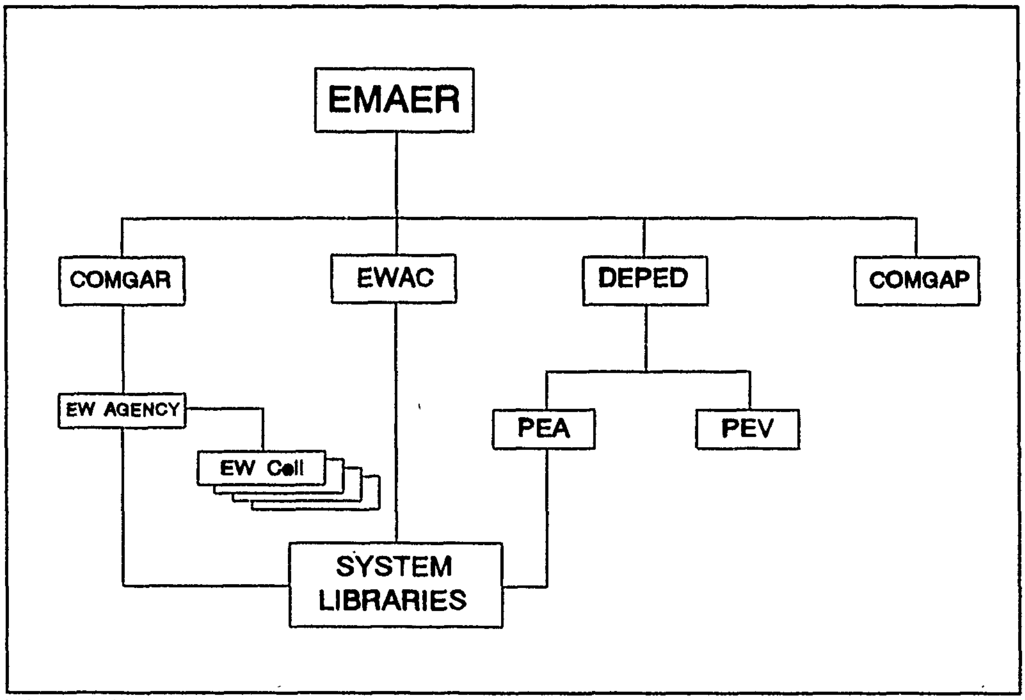

Figure 17: EWRL Organizational Structure

A. DISCUSSION

The goal of the EWRL Program is to ensure standardized and predictable identification/responses in all reprogrammable EW systems. The source of standardized emitter parametrics to support the program is the Emitter Reference File (ERF). The EW Analysis Center provides routine administration of the EWRL program and maintains the ERF. Parametric data for the ERF comes from various intelligence sources, but the EWRL Program is the sole user. It contains friendly, non-hostile and threat parameters, platform data, and general order of battle.

Reporting to the General Air Command (COMGAR), the EW Agency develops formatted EW libraries for each system. These libraries are forwarded to the Electronic Division (PEA), subordinate to the Department of Research and Development (DEPED), where they are coded, tested for proper responses and returned to EW Agency for distribution to Operational Units.

B. ACTION

This Section describes the functional responsibilities for each level or sector involved in the EWRL Process within the Brazilian Air Force.

1. Chief of High Staff of Air Force

a. Direct and coordinate the EWRL process within the Brazilian Air Force.

b. Monitor system funding level for all system libraries.

c. Maintain liaison with Joint Chief of Staff (EMFA) to ensure that, where possible, the EWRL Program is integrated with similar efforts in the Brazilian Army and Brazilian Navy.

d. Establish requirements for future EW reprogrammable systems.

2. **General Air Commander**

a. Determine required contents of tactical EW libraries under their cognizance.

b. Determine specific libraries needed for each Regional Air Command (COMAR) and establish priorities among different system libraries.

c. Determine required threat, friendly, and non-hostile signals, their priority and necessary supporting material.

d. Recommend prioritized systems for EW flagging[2] development.

e. Direct dissemination of new/updated EWRLs and operator aids.

f. Include EW reprogramming in Air Force/Joint exercises.

3. **General Support Commander**

This Command will provide, by means of the Material Directorate (DIRMA), maintenance and technical support for all the equipments involved in the EWRL process.

4. **Department of Research and Development**

Under this Department there are two Divisions that will work in the EWRL Program: the Applied Electronic Division (PEA) and the Inflight Test Division (PEV).

*a. **PEA (Applied Electronic Division)***

- Provide technical support for the maintenance and continued enhancement of the ERF.
- Provide library data/format requirements to the EW Agencies/EWAC.
- Incorporate ECM techniques into EW system libraries as required.
- Maintain documentation for specific EW system library configuration.

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[2] Process to automatically test ELINT data against the EW system to determine whether proper reaction(s) would occur.

- Produce tactical EW libraries[3] using equipment specific data formats.[4]

- Perform engineering analysis for validation and verification to ensure compatibility with other EW systems, correct signal identification and appropriate jamming response.

- Provide support for operational reprogramming exercises.

b. PEV (Flight Test Division)

Provide the inflight test and validation of the new/updated library, when applicable.

5. EW Analysis Center (EWAC)

a. Advise the Chief of EMAER in all the EW related subjects.

b. Provide routine administration of the EWRL program.

c. Maintain EWRL data base using all available source intelligence.

d. Compile, update, process and distribute (quarterly) the Emitter Reference File (ERF).

e. Coordinate with EW Agency and PEA for EWRL format criteria and software update cycles.

6. EW Agency

a. Assist COMGAR in determining formatted EW library content and update requirements. quantities and priorities among EW systems.

b. Utilize ERF data to develop formatted EW libraries.

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[3] Library engineered from the Formatted EW Library. It is coded, integrated into a specific system operational program, tested and validated.

[4] Formatted radar parametric data by the EW Agency from the ERF derived EWRL Data Base. Format requirements are defined by the original equipment manufacturer.

c. Facilitate feedback within the EWRL system by:

- Disseminating EWRL feedback report forms to EW Cells.

- Analyzing EWRL feedback reports to determine required parametric or platform modification.

- Coordinating with EWAC and PEA for recommended changes to specific libraries.

d. After EWAC certification, distribute EW libraries.

e. Provide training libraries as directed by COMGAR.

7. EW Cell

a. Assist specified command in EWRL System under their cognizance.

b. Provide support to operational reprogramming exercises.

c. Facilitate feedback within the EWRL System by:

- Disseminating EWRL feedback report forms to Operational Units.

- Analyzing EWRL feedback reports to propose parametric or platform modification.

8. Operational Unit

a. Report any library discrepancies and other feedback as prescribed by COMGAR.

b. Submit recommendations for EWRL improvements to EMAER, via the chain of command.

C. SUMMARY

COMGAR will initiate the request for a new or updated library or endorse a change request from a subordinated command.

The EW Agency, with assistance from the EWAC, will select and prioritize a list of emitters to be included in the update. Once compiled, this list is formatted and then forwarded to the PEA.

The PEA will convert the formatted parameters into a tactical EW library that conforms to the hardware requirements of the EW system(s) for which it is intended. The PEA will then test and validate each element of the library to ensure its accuracy and proper integration with other platform systems, and return the new/updated library to the EW Agency.

When directed, a certified copy of the tactical EW library will be distributed to Operational Units by the EW Agency based on procedures and schedules that have been coordinated between the EW Agency, EWAC, Specified Commands and COMGAR.

Figure 18 shows the EWRL System.

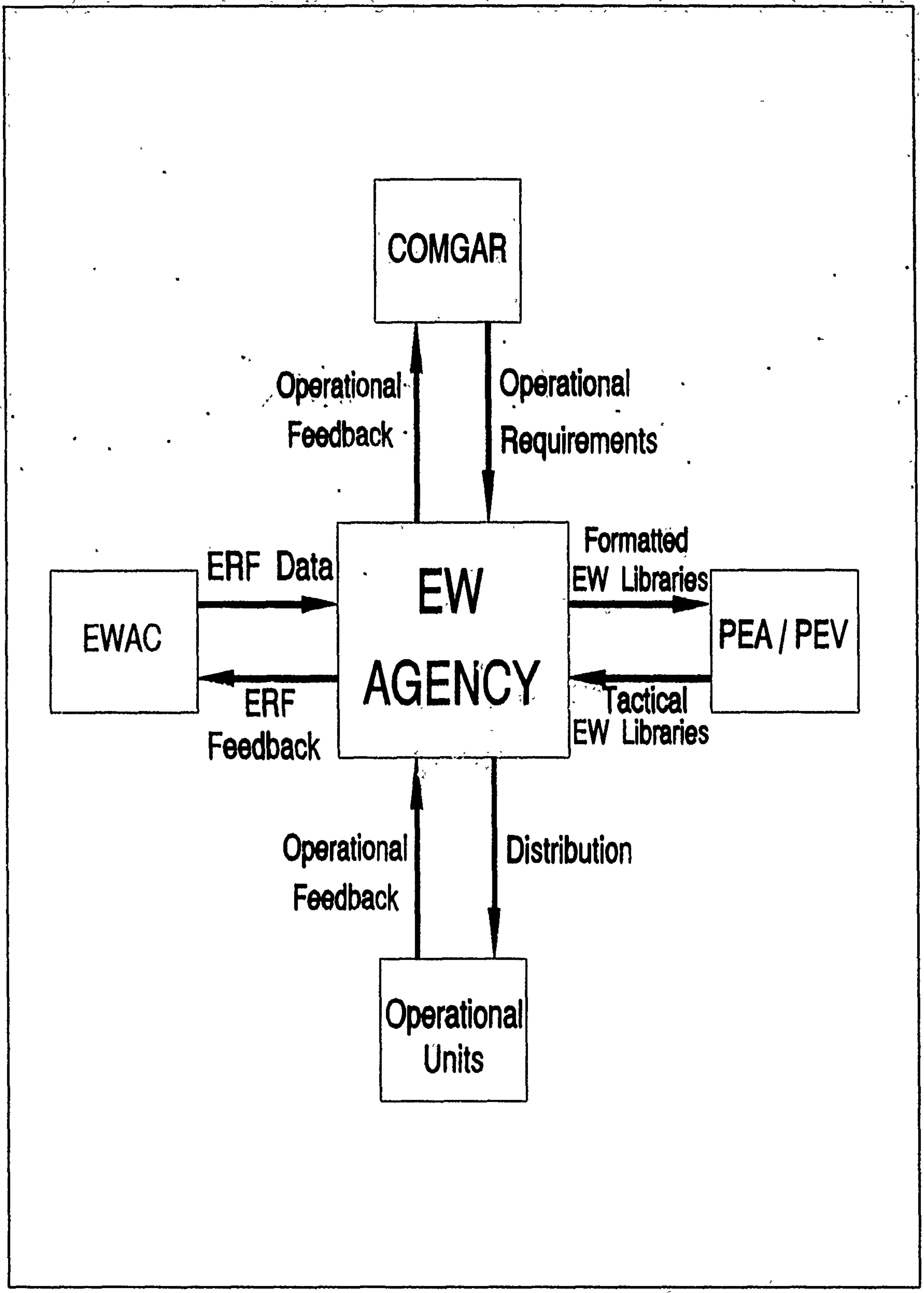

Figure 18: EWRL Process

V. UDF LIBRARY UPDATE PROCESS

This chapter is based on the document Electronic Warfare Software Support Activity (EWSSA) Library Update Proce s, that describes the process and functional responsibilities associated with the UDF library update process within the Electronic Warfare Directorate's EWSSA located at the Pacific Missile Test Center (PMTC), Point Mugu, California.

Chapter IV focused on the organization and functional responsibilities for the development and distribution of EWRL in the Brazilian Air Force. This chapter will discuss the library update process. Figure 19 shows the process functions. The explanation of each step follows.

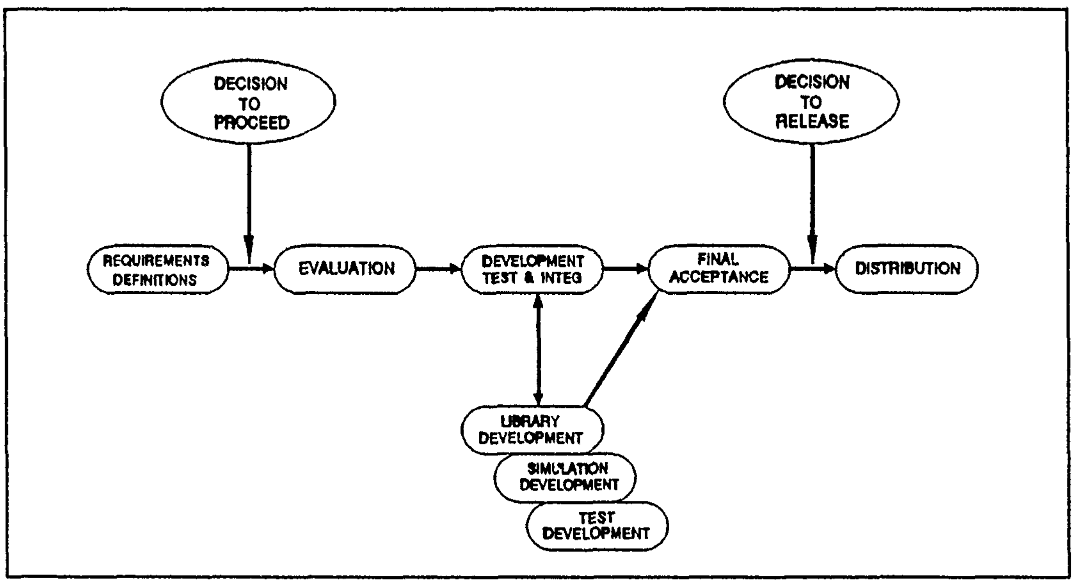

Figure 19: Library Update Process

A. REQUIREMENTS DEFINITION

Discussions or requests for UDF library updates originate in numerous ways including phone conversations, receipt of an STR (software trouble report), submission of EWRL feedback reports, or requirements identified in message traffic. Regardless of how a request originates, authorization for the UDF library update must be given by the General Air Commander (COMGAR).

1. EWRL Feedback Reports

An EWRL Feedback Report provides situational feedback between producers of EW libraries and EWRL users. When routed to and approved by COMGAR, requirements identified in these reports can be incorporated into library updates as appropriate.

2. Threat Library Update Conference

The EMAER, by means of the EWAC, will schedule an annual Threat Library Update Conference to review update requests, solicit comments, and encourage open discussions regarding input for new library development. This conference provides a forum where operational users, representatives from involved commands, intelligence officers, technical and engineering officers can speak face-to-face over issues regarding library updates. Representatives of other services will be invited, as necessary. The primary goal of this forum is to produce a preliminary list of requirements and emitters to be included in the next update.

B. EVALUATION

The EW Agency must evaluate numerous issues in order to decide whether or not to proceed with library development. In this evaluation the following items are considered:

- Does a legitimate operational requirement exist for the update?
- Will the scheduling of the requested update conflict with an existing update schedule?
- Are the list of emitters and associated parameters complete for the update?
- Is the update considered to be routine or a rapid reprogramming effort?

Before the EW Agency can recommend that library development proceed, each of these questions must be satisfied.

To answer these questions the following points must be emphasized:

- COMGAR is the cognizant activity responsible for approving a request to update and authorizing a library release. The request, in a formal message, establishes the legitimacy of the operational requirement.
- COMGAR, or even the EMAER, may be asked to provide additional direction to prioritize the update workload.
- Change definition: For new library development this definition is a prioritized list of candidate emitters and their associated parametrics. For modifications to an existing library, the parameters for the additions and/or modifications are required. Deletions must be explicitly identified.
- The operational objectives to be satisfied by the change must be identified.
- The Operational Units and platforms involved must be identified in order to facilitate coordination with other programs.
- Tactical considerations outweigh technical expediency.

C. LIBRARY DEVELOPMENT, TEST AND INTEGRATION

1. Library Development

a. Library Change Proposal (LCP)

When a UDF library update is planned, the EW Agency prepares a formal LCP. This proposal becomes the vehicle through which changes to an approved configuration baseline is authorized by COMGAR. Approval of this proposal provides authority to implement the change.

b. Software Trouble Reports (STR)

These reports are an important means of change control within the library update process. During the update process, these reports originate primarily from the library development specification. An individual STR is written for each emitter specified. As the update process continues, status accountability can be provided for each emitter. Upon final acceptance of the library, these STRs provide a complete, chronological history of the emitter's disposition.

c. Engineering Calculation

Using the intelligence parametrics provided in formatted libraries, systems engineers will perform calculations to custom tailor the threat parametrics received to fit the system in which the library will be deployed.

d. Development of the Initial Library Data Base

The data generated from the engineering calculations must be entered into a data base in preparation for UDF generation. Each data base is organized so that data is automatically loaded into their respective files and tables during UDF generation. This data base is now considered a UDF load image from which the initial UDF is generated and prepared for initial testing.

2. Simulation Development

To ensure that the library produced by the PEA correctly responds to threats in the operational environment, the PEA develops realistic, complex threat simulations to be used in closed-loop, radio frequency injected, simulation testing. Once created, these simulation are used in testing library response in both single and multiple threat environments. Each individual emitter included within an update is tested.

3. Test Development

Within the PEA, extensive library testing is done in support of engineering development. This testing includes parametric testing of each individual emitter in the update, system reaction within a multiple threat environment, and system test in a stand-alone mode of operation.

D. FINAL ACCEPTANCE

When library development by the PEA is completed, the new library, with all supporting engineering documentation and comments, is now ready for formal acceptance, verification and validation. The PEA must now verify that all emitters listed in the original Library Requirements Definition Document are included in the library and validate to ensure that the library responds as required within the parametric boundaries provided by the EW Agency. In preparation for final verification and validation, the appropriate test plans and procedures have been prepared.

When testing is completed, a formal test report is written. This report includes the test philosophy, test findings, test data, engineering comments, and recommendations as to the overall reliability and release of the library.

1. Discrepancy Report (DR)

In the event that a discrepancy is discovered during final acceptance testing, the test engineers will prepare a DR which describes the discrepancy in sufficient detail to permit analysis and evaluation by the system engineers. The system engineer will indicate the action taken to correct the discrepancy in the designed section of the DR. When the test team verifies that the discrepancy has been corrected, the DR will receive a control number and will be archived for record purposes.

2. Flight Testing

The inflight validation will be conducted by the PEV (Flight Test Division), subordinated to the DEPED.

If requested, the PEA can also assist in the arrangements for inflight validation of a library prior the final acceptance. The logistics of this arrangement are currently outside the control of the PEA and should be requested by the EW Agency, via COMGAR and DEPED. The PEA will provide assistance as required in the preparations and conduct of this test.

3. Decision to Release

After the completion of the final acceptance, with the inflight validation, if applicable, the PEA will forward the new tactical library, with all the test reports, to the EW Agency. The EW Agency will analyze all the test reports and advise the General Air

Commander as to the releasability of the new library. It must again be emphasized that the decision to release is made by the COMGAR only.

E. DISTRIBUTION

When the library is released by COMGAR, the EW Agency distributes it the operational units. As modification to aircraft and equipment may be made only by the COMGAP, a technical directive (TD) is issued by the EW Agency and forwarded to COMGAP.

1. Technical Directive (TD)

A TD directs the accomplishment and recording of a configuration change; that is, a material change, a repositioning, a modification, or an alteration in the characteristics of the equipment. Modifications to aircraft and equipment may be made only upon receipt of an approved TD. A TD is assigned a category in accordance with the importance and urgency of accomplishing the work involved. The categories of TDs are:

- Immediate: This category shall be used when an unsafe condition exists which could result in fatal or serious injury to personnel or destruction or extensive damage to valuable equipment. It will require execution prior to the next flight.
- Urgent: This category shall be used when potentially hazardous conditions exist, which, if uncorrected, could result in injury to personnel, damage to valuable property or unacceptable reduction in operational efficiency. Such conditions are tolerable within a definite time limit.
- Routine: This category shall be used when conditions are, if uncorrected, become a hazard through prolonged usage, or have an adverse effect on the operational life or general service utilization of equipment.
- Record Purpose: This category shall be used when a modification has been incorporated by the contractor or in-house activity and does not require retrofit or modification of the equipment.

2. Installation Procedures

The PEA will provide detailed instructions for the installation of the new library version. This documentation will include:

- A complete list of documents, materials, and equipment necessary for installation of the new release.
- A set of step-by-step instructions for installation of the new software including system response associated with each step.
- A set of instructions for dealing with anomalous or unexpected conditions.
- An installation checkoff and verification form to be returned to the EW Agency and PEA.

3. Documentation Change Pages

For all new library releases and for all library revisions, it is necessary to issue either changes to existing documents or to issue new updated documents. Each library revision will contain modifications to either the threat emitter list or the parametric data or both.

F. SUMMARY

In the library update process some steps must be followed in order to get the maximum efficiency and operationality. Figure 19, on page 48, summarizes these steps.

Authorization for a UDF Library Update must be given by the COMGAR.

In the evaluation phase, all the objectives must be identified and satisfied to proceed with the library change.

The library development, test and integration will be done by the PEA (Applied Electronic Division) after they receive the formatted EW Library from the EW Agency.

When library development by the PEA is completed, it is now ready for formal acceptance, verification and validation. Inflight validation will be done by the PEV (Flight Test Division) if required.

The development of the test and evaluation plan will be done by the EW Agency, advised by the EWAC). It must be emphasized that PEA does technical tests, and the operational tests will be conducted by COMGAR through its EW Agency.

After the release decision is given by the COMGAR, the EW Agency will distribute the new/updated library to the Operational Units, for installation in accordance with the priority given by the technical directive (TD).

VI. CONCLUSIONS

When talking about the RWR it is worthwhile to remember that modern Radar Warning Receivers are usually one subsystem of an EW suite of subsystems designed to identify the threat, take active electronic countermeasures, and, in some cases, launch an anti-radiation missile at the threat emitter. The functional integration of these subsystems is crucial to aircraft mission success.

These systems are only effective if "they have a high probability of intercept, a fast reaction time and must not mistakenly identify a harmless or friendly signal as lethal or vice-versa." [Ref. 3: p. 4]

To fulfill this objective it is essential to have an accurate and constantly updated threat library. Only a correct and well oriented reprogramming process will ensure proper threat responses.

Given the importance updated libraries play in mission success, this work tries to outline a reprogramming process for the Brazilian Air Force. In Chapter I, a brief description of the Brazilian Air Force was done, with emphasis on Electronic Warfare. Chapter II provides background to better understand the EW reprogramming process. Chapter III summarizes the EWRL process in the US Navy. Chapter IV outlines the functional process, flow chart and responsibilities for the development and distribution of tactical EWRL. Finally, Chapter V describes the steps followed in the library update process.

Nothing was said about an Emergency/Urgent Reprogramming Process, but when an emergency situation occurs, there may not be enough time to follow all the steps previously described. Therefore, an Emergency Reprogramming Plan must still be established in order to supplement or by-pass the normal structure for the duration of an emergency reprogramming requirement. The overall idea is to define the concept of operations of an Emergency Reprogramming Center (ERC) manned round-the-clock. This center would have personnel from the EWAC, EW Agency and PEA. The ERC would also have the authority necessary to implement emergency software changes to EW systems.

In the current organization of EW in the Brazilian Air Force, most of responsibilities and functions are attributed to the EWAC. In this work, after analysis of the EWRL process in the US Navy, the author made a decision about where the EWRL process should be centered. The most logical choice was the EW Agency, under the General Air Commander. This choice was based on operational concepts. EW must be managed by operational personnel who have the expertise to integrate EW into air operations. The EWAC will take care of the Emitter Reference File (ERF), collecting information from all available sources and coordinating with the EW Agency for recommended changes to library.

This work is not the final word, but it is hoped it can be used as a starting point, or even as a reference for the establishment of the Brazilian Air Force Reprogramming Process.

OPNAV INSTRUCTION C3430.23A

IN REPLY REFER TO
OPNAVINST C3430.23A
Ser 762F/9C641441
10 AUG 1989

CONFIDENTIAL -- Unclassified upon removal of enclosure (3)

OPNAV INSTRUCTION C3430.23A

From: Chief of Naval Operations

Subj: TACTICAL ELECTRONIC WARFARE REPROGRAMMABLE LIBRARY (EWRL) SUPPORT PROGRAM (U)

Encl: (1) EWRL Definitions and Architecture
(2) Electronic Warfare Systems and Support Activities
(3) Rapid Reprogramming Objectives (U)
(4) EWRL Working Groups
(5) Naval Emitter Reference File (NERF) Feedback Report Form, OPNAV 3430/2
(6) Electronic Warfare Reprogrammable Library Feedback Report Form, OPNAV 3430/3

1. Purpose. To issue responsibilities and procedures for defining, developing, maintaining, managing and distributing tactical Electronic Warfare (EW) reprogrammable libraries for automated non-communication EW systems. This instruction has been substantially changed and should be read in its entirety.

2. Cancellation. OPNAVINST C3430.23.

3. Scope. This instruction addresses libraries for software/firmware reprogrammable electronic warfare support measures (ESM), electronic countermeasures (ECM) and anti-radiation missile (ARM) systems. Intelligence collection systems and non-EW systems are not covered in this instruction.

4. Background

a. The Navy relies heavily upon electronic sensors and systems to detect, localize and target the enemy. Simultaneously, we depend upon electronic systems to defend friendly forces from enemy attack by controlling or denying the enemy's utilization of the electromagnetic spectrum.

b. Reliance on electronic sensors and their spread to all parts of the electromagnetic spectrum has generated a need for computer augmentation of EW systems. It is no longer possible for a human operator to manually scan, monitor and analyze the spectrum and respond to threats in a timely manner.

c. Modern EW systems are designed with computer aided recognition tools which allow the systems to sort and identify threats in a complex electromagnetic environment. Most EW systems rely upon electronically stored parameters, organized in libraries to identify detected signals. These libraries, like any reference material, must be current and accurate in order to insure proper EW system response to a threat.

d. Electronic libraries take many forms and utilize many different materials and techniques to store information. Specific procedures for developing, maintaining, managing and distributing these libraries are established in this instruction.

5. Discussion

a. The goal of the EWRL Support Program is standardized and predictable identifications/responses in all EW reprogrammable systems.

b. The Naval Emitter Reference File (NERF) has been established as the common reference source for support program library information. The EW Operational Programming Facility (EWOPFAC) provides routine administration of the EWRL program and maintains the NERF. NERF utilizes data from various intelligence sources and is maintained specifically for the EWRL Support Program. NERF contains friendly, non-hostile and threat parameters, platform data, general order of battle and theater specific parametrics.

c. The EW Operational Programming Detachments (EWOPDETs), reporting to the Fleet Commander-in-Chiefs (FLTCINCs), develop formatted EW libraries for each formally supported system. These libraries are forwarded to the appropriate Tactical Systems Support Center/Software Support Activity (TSSC/SSA) where they are coded, tested for proper responses, and distributed to Fleet users.

d. During EW system development, EW library structure is the responsibility of the cognizant systems command or developing agency, but early integration with the EWRL Support Program is required. Developmental library data used for software testing shall be drawn from the NERF.

e. Enclosure (1) provides definitions for the EWRL Support System and depicts the architecture for the EWRL support process.

f. Enclosure (2) lists the EW reprogrammable systems and the associated Navy support activities for these systems.

g. Enclosure (3) contains rapid reprogramming objectives and response time goals which will be used as guidance to develop enhanced EW system responsiveness and flexibility.

h. Enclosure (4) describes the composition of EWRL working groups established to provide input and assist in the management of the EWRL Support Program.

i. Enclosure (5), OPNAV 3430/2, is provided to facilitate feedback to EWOPFAC concerning NERF quality.

j. Enclosure (6), OPNAV 3430/3, is provided to facilitate feedback on a situational basis between producers of EW libraries and Fleet EWRL users.

6. Action

a. Chief of Naval Operations (CNO) (OP-07 (OP-76))

(1) Direct and coordinate the EWRL support program within the Navy.

(2) Coordinate EWRL production needs and approve emergent requirements.

(3) Monitor system support funding levels for geo-tailored libraries with appropriate resource sponsors.

(4) Provide requirements to the cognizant systems command for the development of new systems and the conversion of existing systems to improve standardization and promote commonality.

(5) Maintain liaison with Joint Chiefs of Staff (JCS) and other services/agencies to ensure that, where possible, the EWRL program is integrated with similar efforts throughout the Department of Defense.

(6) Provide guidance and direct the efforts of the EWOPFAC.

(7) Review validity of all NERF emitter and intelligence order of battle sources as required.

b. <u>Chief of Naval Operations (OP-02, 03, 05)</u>

(1) Fulfill requirements of resource sponsorship for EWRL Support Program (OP-03 only).

(2) Provide program support funding for platform-unique geo-tailored EW libraries through the service life of individual systems.

(3) Promote the concepts outlined in enclosure (3) for establishing requirements for future EW reprogrammable systems.

c. <u>Fleet Commander-in-Chief</u>

(1) Perform functions of EWOPDET reporting senior.

(2) Determine required contents of tactical EW libraries under their cognizance.

(3) Determine specific libraries needed for each Naval operating area and optimum frequency of update, establish priorities among different system libraries and submit geo-tailored EW library requirements to OP-76 for coordination with platform sponsors.

(4) Determine required threat, friendly, and non-hostile signals, their priority in both embedded and field reprogrammable libraries, and necessary supporting material such as operator aids.

(5) Recommend prioritized systems for EW flagging development.

(6) Direct dissemination of new/updated EWRLs and operator aids.

(7) Monitor the tactical EW library feedback program to ensure responses are accurate, timely and complete.

(8) Include EW reprogramming in Fleet/Joint exercises.

(9) Submit new/additional library requirements to CNO (OP-76) for funding coordination with resource sponsors.

(10) Provide administrative support as EWOPFAC reporting senior (Commander in Chief Atlantic Fleet (CINCLANTFLT) only).

d. Commander, Space and Naval Warfare Systems Command

(1) Provide overall management and acquisition support for the EWRL Support Program. Specifically:

(a) Manage the automation of the EWOPDET library building process for EW reprogrammable systems, promoting commonality of library building techniques where possible.

(b) Provide technical support for the maintenance and continued enhancement of the NERF.

(c) Establish and maintain configuration management policies and practices for the EWRL Support Program.

(d) Act as the designated Configuration Control Board (CCB) chairman.

(e) Ensure compliance with EWRL support procedures and guidance for the rapid reprogramming objective contained in enclosure (3) during the system development process. In conjunction with this task, ensure growth to incorporate screening and EW flagging in the library build process so that changes in the EW threat environment can be identified rapidly.

(f) Procure hardware and software, and provide system engineering for the EWOPFAC and EWOPDETs in order to meet the mission of the EWRL support program.

(2) Act as EWRL representative to promote integration of EWRL data with Navy command and control systems.

e. Commanders, Systems Commands

(1) Administer and oversee performance of TSSCs/SSAs.

(2) Designate and provide resources for TSSCs/SSAs to support specific reprogrammable EW systems.

(3) Ensure that TSSCs/SSAs are capable of effective implementation of EWRL program.

(4) Notify FLTCINCs, TSSC/SSA, EWOPFAC and EWOPDETs of research and development, new production or modified EW systems requiring EWRL support.

(5) Ensure that pre-production libraries for software testing of EW systems during system development are drawn from the NERF.

(6) Include EW system library requirements in the system developmental milestone process.

(7) Recommend design practices to enhance EWRL flexibility by standardizing data/format requirements and simplifying hardware/software to rapidly incorporate changes.

(8) Review and validate requirements for NERF distribution and forward requests to OP-76.

f. <u>Tactical System Support Centers/Software Support Activities</u>

(1) Produce tactical EW libraries using formatted EW libraries.

(2) Perform engineering analysis for validation and verification to ensure compatibility with other EW systems, correct signal identification and appropriate jamming response.

(3) Incorporate ECM techniques into EW system libraries as required.

(4) Coordinate with EWOPDETs concerning any desired formatted EW library changes.

(5) Provide library data/format requirements to the EWOPFAC/EWOPDETs.

(6) Integrate operational programs and new/updated formatted EW libraries.

(7) Verify recognition algorithms.

(8) After EWOPDET certification, distribute tactical EW libraries. Provide supporting documentation that includes a narrative summary of modified EW capabilities, operator-oriented instructions/clarification and technical material for implementing the change.

(9) Maintain documentation for specific EW system library configurations.

(10) Maintain specific EW systems tactical EW library configuration control/archives.

(11) Provide training libraries as directed by cognizant systems command.

(12) Produce computer software models and algorithms for assigned reprogrammable EW systems to be used by EWOPFAC/EWOPDETs for EW flagging and preliminary evaluation of selected signals for impact on the appropriate EW system (detailed analysis/evaluation will be done at respective TSSC/SSA).

(13) Coordinate with EWOPDETs on system problems for feedback reports from users of tactical EW libraries and provide response.

(14) Recommend design practices to enhance EWRL flexibility by standardizing data/format requirements and simplifying hardware/software to rapidly incorporate changes.

(15) Provide support to fleet reprogramming exercises.

(16) Provide training to EWOPDET/EWOPFAC personnel on characteristics of equipment being supported. Training will be coordinated and scheduled by EWOPFAC.

g. Commander, Naval Security Group. Task Naval Security Group Activity (NSGA), Charleston, to provide U.S. Navy emitter data to EWRL producers.

h. Naval Research Laboratory (NRL), Naval Weapons Center (NWC) and Pacific Missile Test Center (PMTC)

(1) Develop, evaluate and provide algorithm descriptions of ECM techniques to appropriate TSSCs/SSAs for Surface and Tactical Air EW reprogrammable systems.

(2) When research reveals new threat system vulnerabilities, capabilities and/or new electronic parameters, ensure EWOPDETs and EWOPFAC are included in distribution of this new information.

i. EW Operational Programming Facility

(1) Report to CINCLANTFLT for administrative control and support. Liaison with CNO (OP-76/OP-351) and Space and Naval

Warfare Systems Command (SPAWARSYSCOM PMW-162) for EWRL Support Program direction and funding support.

(2) Execute SPAWARSYSCOM direction in maintaining EWRL production system software configuration.

(3) Act as the primary liaison office for Fleet EWRL support.

(4) Liaison with producers of other data bases such as those resident at Intermediate Processing Centers (IPCs), National Security Agency (NSA), Defense Intelligence Agency (DIA), Scientific and Technical (S&T) Intelligence Centers and NSGA, Charleston.

(5) Coordinate with TSSC/SSAs for data format requirements.

(6) Coordinate with NSGA, Charleston for U.S. Navy parametric and emitter/platform fit data.

(7) Provide EWRL library generation application software support for future automated EW systems.

(8) Compile, update, process and distribute (quarterly) the all-source worldwide NERF.

(9) Ensure quality assurance for NERF data accuracy and completeness.

(10) Coordinate EWOPDET TSSC/SSA training requirements and schedule training with the appropriate SSAs.

(11) Officer in Charge EWOPFAC act as special assistant to OP-76 EWRL program sponsor. Fulfill requirements as the central point of contact for routine EWRL matters.

j. <u>EW Operational Programming Detachment</u>. A consolidation of Electronic Warfare Operational Programming Detachment Europe (EWOPDETEUR) and Electronic Warfare Operational Programming Detachment Atlantic (EWOPDETLANT) efforts resulted in EWOPDETLANT assuming portions of EWOPDETEUR responsibilities under the new name of EWOPDETLANT/EUR. The following responsibilities apply to EWOPDETLANT/EUR and Electronic Warfare Operational Programming Detachment Pacific (EWOPDETPAC) (specific tasking for EWOPDETEUR is indicated):

(1) Assist FLTCINC staff in determining formatted EW library content, update requirements, quantities and priorities among EW systems. Coordinate with theater Intermediate Processing Center (IPC) and TSSC/SSA for data criteria and update cycle needs. EWOPDETEUR coordinate with CINCUSNAVEUR, Naval Communications Station (NCS) Spain, and EWOPDETLANT/EUR.

(2) Utilize NERF data to develop formatted EW libraries. Supplement NERF data with theater specific all source data as necessary to complete library requirements and resolve threat ambiguites. EWOPDETEUR coordinate with EWOPDETLANT/EUR.

(3) Assist IPC in providing geographically-tailored, formatted EWRL data to designated TSSC/SSAs.

(4) Coordinate with IPC, appropriate TSSC/SSA and EWOPFAC for EWRL data format criteria.

(5) Coordinate and assist IPC in preparing operator interactive libraries, system specific recognition aids, Hull-to-Emitter Correlation (HULTEC) data and rapid reprogramming/flagging parametric support as required by the Fleet Commander. EWOPDETEUR coordinate with EWOPDETLANT/EUR and provide rapid reprogramming/flagging support.

(6) Coordinate with IPC to extract and assemble parametric and platform data.

(7) EWOPDETLANT/EUR will develop Atlantic Theater libraries, coordinate with EWOPDETEUR for developing European Theater libraries and EWOPDETPAC will develop Pacific/Indian Ocean Theater libraries. World wide library content will be coordinated between EWOPFAC, EWOPDETs and appropriate TSSC/SSA (EWOPFAC will be the lead organization).

(8) Library production software and top level software architecture for mainframe computers and personal computers will be common between EWOPDETLANT/EUR and EWOPDETPAC where possible.

(9) Using enclosure (5), provide feedback on NERF content to the EWOPFAC. EWOPDETEUR coordinate with EWOPDETLANT/EUR.

(10) Facilitate feedback within the EWRL system by:

(a) Coordinating with appropriate TSSC/SSA, Technical Guidance Units and Fleet Anti-Submarine Warfare Operations

Centers to disseminate EWRL feedback report forms to Fleet EWRL users.

(b) Analyzing EWRL feedback reports to determine required parametric or platform modifications. Coordinate with TSSC/SSA for recommended changes to specific libraries. EWOPDETEUR provide input to EWOPDETLANT/EUR.

(11) Send urgent EWRL change messages addressing critical changes to threat parametrics in system libraries to fleet units with copies to the EWOPFAC and applicable TSSC. EWOPDETEUR will provide copies to EWOPDETLANT/EUR and EWOPFAC.

(12) Enhance rapid reprogramming by screening and forwarding emitter parametric anomaly flags produced at the IPC to FLTCINCs, applicable TSSC/SSA and EWOPFAC.

(13) Provide liaison function between the appropriate Fleet and the EWRL Support Program. EWOPDETEUR provide results to EWOPDETLANT/EUR.

(14) Coordinate and approve all library changes recommended by applicable TSSCs/SSAs. For the FLTCINC, certify and approve final library configuration.

(15) Coordinate training requirements with EWOPFAC. EWOPDETEUR coordinate requirements with EWOPDETLANT/EUR.

(16) Provide theater specific parametrics to EWOPFAC for inclusion in the NERF. EWOPDETEUR provide parametrics to EWOPFAC.

(17) EWOPDETPAC will develop and maintain the Standardized Platform Abbreviation Listing (SPAL) which will provide the EWRL support program with a common, standardized listing of 4, 6, 8, 12, and 20 character platform abbreviations. Semi-annual updates will be provided to the EWOPFAC for inclusion in the NERF.

(18) EWOPDETLANT/EUR will develop and maintain the Standardized Emitter Abbreviation Listing (SEAL) which will provide the EWRL support program with a common, standardized listing of 4, 6, 8, 12, and 24 character emitter abbreviations. Semi-annual updates will be provided to the EWOPFAC for inclusion in the NERF.

k. Navy Office of Technology Transfer and Security Assistance. Provide specific guidance on, and coordinate release of, EW library data to foreign governments.

l. Fleet Units

(1) Use enclosure (6) to report any library discrepancies and other feedback as prescribed by the FLTCINC.

(2) Submit recommendations for EWRL improvements to OP-76 via the chain of command.

m. Intermediate Processing Centers. This section is provided to show the IPC relationship in the Navy's EWRL Support Program. IPC Support was tasked by JCS message 280019Z JAN 84 which outlined the following responsibilities:

(1) Maintain theater specific EWRL data base using all source intelligence for appropriate areas of responsibility.

(2) Provide geographically-tailored, formatted EWRL data to designated engineering facilities (TSSCs/SSAs) as specified by CNO and FLTCINCs.

(3) Coordinate with collocated EWOPDET, appropriate TSSC/SSA and EWOPFAC for EWRL data format criteria, software update cycles, geo-tailoring and operational feedback requirements.

(4) Prepare operator interactive libraries, recognition aids, HULTEC data and rapid reprogramming/flagging parametric support as required by the FLTCINC and coordinated with collocated EWOPDET.

7. Reports and Forms

a. Reports. The following requirements are approved for three years only from the date of this instruction.

(1) The EWRL NERF Feedback Report, OPNAV 3430-2, addressed in paragraph 6j(9) and enclosure (5).

(2) The EWRL Feedback Report, OPNAV 3430-3, addressed in paragraph 6l(1) and enclosure (6).

b. Forms

(1) OPNAV 3430/2, NERF Feedback is provided as enclosure (5).

(2) OPNAV 3430/3, EWRL Feedback, is provided as enclosure (6).

C. R. MCGRAIL
Rear Admiral, U. S. Navy
By direction

Distribution:
(see page 13)

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EWRL DEFINITIONS AND ARCHITECTURE

System Considerations

EW Reprogrammable Systems	Computer controlled or automated electronic warfare systems that have reprogrammable software or firmware update capabilities. For purposes of this OPNAVINST only non-communication systems are considered.
Embedded Library	That part of the EW library that is provided by the TSSC/SSA and cannot be changed or modified by the equipment operator..
Field Reprogrammable Library	That library, or part of the EW library, that can be reprogrammed underway or in the field.
EW Flagging	Process to automatically test ELINT data against specific EW system logic and limits to determine whether proper reaction would occur or if an effective countering capability is present.
Rapid Reprogramming	Reprogramming of tactical EW libraries to counter changes in threat signal environment or characteristics in response to rising tensions, crisis or war.

DATA HIERARCHY

Naval Emitter Reference File (NERF)	All-source emitter data base for developmental applications and generation of worldwide libraries. It contains friendly, non-hostile and threat parametrics, and electronic order of battle data. NERF is a compilation of existing EW data in the format required to support Navy EW systems.
EW Library List	The prioritized emitter list containing signals of interest for a particular EW system. Developed by FLTCINC/EWOPDET, reflecting geotailored/global operational requirements.
Formatted EW Library	Library produced by the IPC/EWOPDET from the EW Library List and the worldwide/ theater EWRL data base derived from the NERF.
Tactical EW Library	Produced by the TSSC/SSA from the Formatted EW Library. It is integrated into the specific system operational program, tested, validated and provided directly to the fleet user.

Enclosure (1)

ORGANIZATIONS

EW Operational Programming Detachment (EWOPDET)	Theater organizations subordinate to FLTCINCs. EWOPDETEUR is located at ROTA, Spain, EWOPDETLANT/EUR is located at Norfolk, VA and EWOPDETPAC is located at Camp Smith, HI. EWOPDETs provide EW equipment library reprogramming support to respective FLTCINCs. EWOPDETPAC and EWOPDETLANT/EUR develop formatted libraries which are delivered to TSSCs/SSAs.
Intermediate Processing Center (IPC)	The Theater Intermediate Processing Centers supporting EWOPDETs are the Atlantic Command Joint Intelligence Center (LANTJIC) and the Intelligence Center Pacific (IPAC). In Europe, the Joint Intelligence Center (JIC) has delegated support of Naval systems to NCS Spain.
EW Operational Programming Facility (EWOPFAC)	Norfolk, VA based central facility for development, production, distribution and maintenance of software for EWRL generation and the NERF.
Tactical Systems Support Center/Software Support Activity (TSSC/SSA)	CONUS based organizations subordinate to Navy System Commands. TSSCs/SSAs receive formatted EW libraries from EWOPDETs and develop, test, validate and distribute tactical EW libraries to Fleet users.

Relationship of these organizations and EWRL data flow is depicted at Figure 1.

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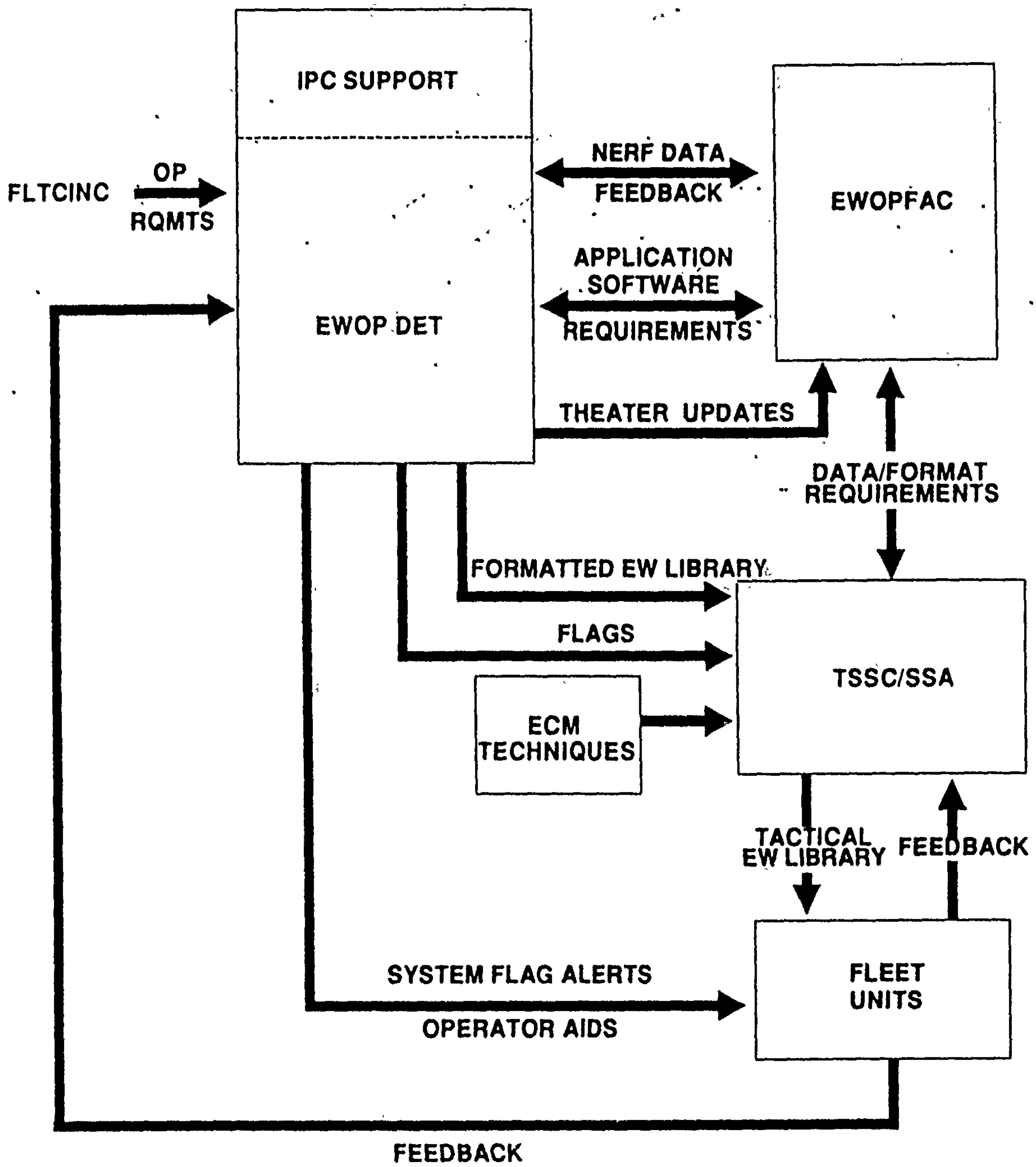

FIGURE 1. EWRL SUPPORT SYSTEM

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ELECTRONIC WARFARE SYSTEMS AND SUPPORT ACTIVITIES

AIR SYSTEMS OP-05 SPONSOR

SYSTEMS	PLATFORM	SYSCOM AGENCY	TSSC/SSA
AAR-47	CH-46E, CH-53D/E, UH-1, AH-1, OV-10, V-22	PMA 253	PMTC
AGM-88	F/A-18A/B/C/D, EA-6B, A-6E SWIP, A-7E	PMA 242	NWC, China Lake
ALE-47	F/A-18A/B/C/D, V-22, EA-6B, SH-60/SH-60B, F-14D, AV-8B, LRAACA	PMA 253	PMTC
ALQ-78	P-3C	PMA 240	NADC
ALQ-99	EA-6B	PMA 234	PMTC
ALQ-126B	A-4M, A-6E/A-6E SWIP, A-7B/C/E, F-4N/S, RF-4B, F-14A, F-18A/B/C/D, EA-6B, KA-6D	PMA 253	PMTC
ALQ-142	SH-60, LAMPS MK3	PMA 266	NADC
ALQ-149	EA-6B	PMA 234	PMTC
ALQ-162	A-4M, A-7E, RF-4B F-4J/S/N, AV-8B	PMA 253	PMTC
ALQ-184	AV-8B	PMA 253	PMTC
ALQ-165	F-14A/D, A-6E SWIP, AV-8B, F/A-18A/B/C/D	PMA 272	PMTC
ALR-45F	A-4M, A-7D/E, AV-8B/C, RF-4B, F-4N/S	PMA 253	PMTC
ALR-45F(V)	RF-4B, A-7E, A-4M	PMA 253	PMTC
ALR-47	S-3A/B	PMA 244	NADC
ALR-59	E-2C	PMA 231	FCDSSA, SD
ALR-66(V)1	SH-2F	PMA 274	PMTC
ALR-66(V)2	P-3A/B	PMA 240	PMTC
(V)3	P-3CU1/3	PMA 240	PMTC
(V)4	E-6A	PMA 271	PMTC
(V)5	P-3CU4/LRAACA	PMA 240	PMTC
ALR-67	A-6E SWIP, F-14A/D, SH-2F, F/A-18A/B/C/D, AV-8B	PMA 253	PMTC

ALR-67 (ASR)	A-6E SWIP, F-14D AV-8B F/A-18A/B/C/D,	PMA 253	PMTC
ALR-73	E-2C	PMA 231	FCDSSA, SD
ALR-76	S-3B, EP-3E, ES-3	PMA 244	
APR-39A(XE-2)	CH-46E, CH-53D/E, AH-1W, UH-1, V-22 OV-10A/D, SH-60B, V-22	PMA 253	PMTC
APR-43	A-4M, F-4S A-7E, RF-4B, AV-8B	PMA 253	PMTC
INEWS	NATF, A-12	PMA 253	PMTC

SURFACE SYSTEMS OP-03 SPONSOR

SYSTEMS	PLATFORM	SYSCOM AGENCY	TSSC/SSA
SLQ-17A(V)2	CV/CVN	NAVSEA 06W1	HAC
SLQ-32(V)1	LKA,LPD, LSD, LST, AE	NAVSEA 06W1	NSWC
SLQ-32(V)2	DD, DDG, FF, FFG	NAVSEA 06W1	NSWC
SLQ-32(V)3	BB, CG, CGN, LHA, LPH, LCC, LHD, AOR, AFS, AO	NAVSEA 06W1	NSWC
SLQ-32(V)4	CV, CVN	NAVSEA 06W1	NSWC
WLR-1H(V)3	CV, CVN, BB	NAVSEA 06W1	NESEC Portsmouth
ALR-66(V)6	PHM	NAVSEA 06W1	GI
ULQ-16	VARIOUS	SPAWAR PMW 143	NESEC Charleston

SUBSURFACE SYSTEMS OP-02 SPONSOR

TYPE 18 ADF	688/726 Class SSN/SSBN	NAVSEA 06W2	NESEC, SD
WLQ-4 (SEA NYMPH)	637 Class SSN	NAVSEA 06W2	NESEC, SD
WLR-8(V)2/5	688/726 Class SSN/SSBN	NAVSEA 06W2	NESEC, SD
WLR-1H(V)1	594 Class SSN	NAVSEA 06W2	NESEC, Portsmouth
WYQ-2	594 Class SSN	NAVSEA 06W2	NESEC, SD

FCDSSA, SD	-	Fleet Combat Direction Systems Support Activity, San Diego, CA
GI	-	General Instrument, Hicksville, NY
HAC	-	Hughes Aircraft Corporation, Fullerton, CA
NADC	-	Naval Air Development Center, Warminster, PA
NESEC	-	Naval Electronic Systems Engineering, Center San Diego, CA and Portsmouth, VA
NSWC	-	Naval Surface Warfare Center, Dahlgren, VA
NWC	-	Naval Weapons Center, China Lake, CA
PMTC	-	Pacific Missile Test Center, Point Mugu, CA

Enclosure (2)

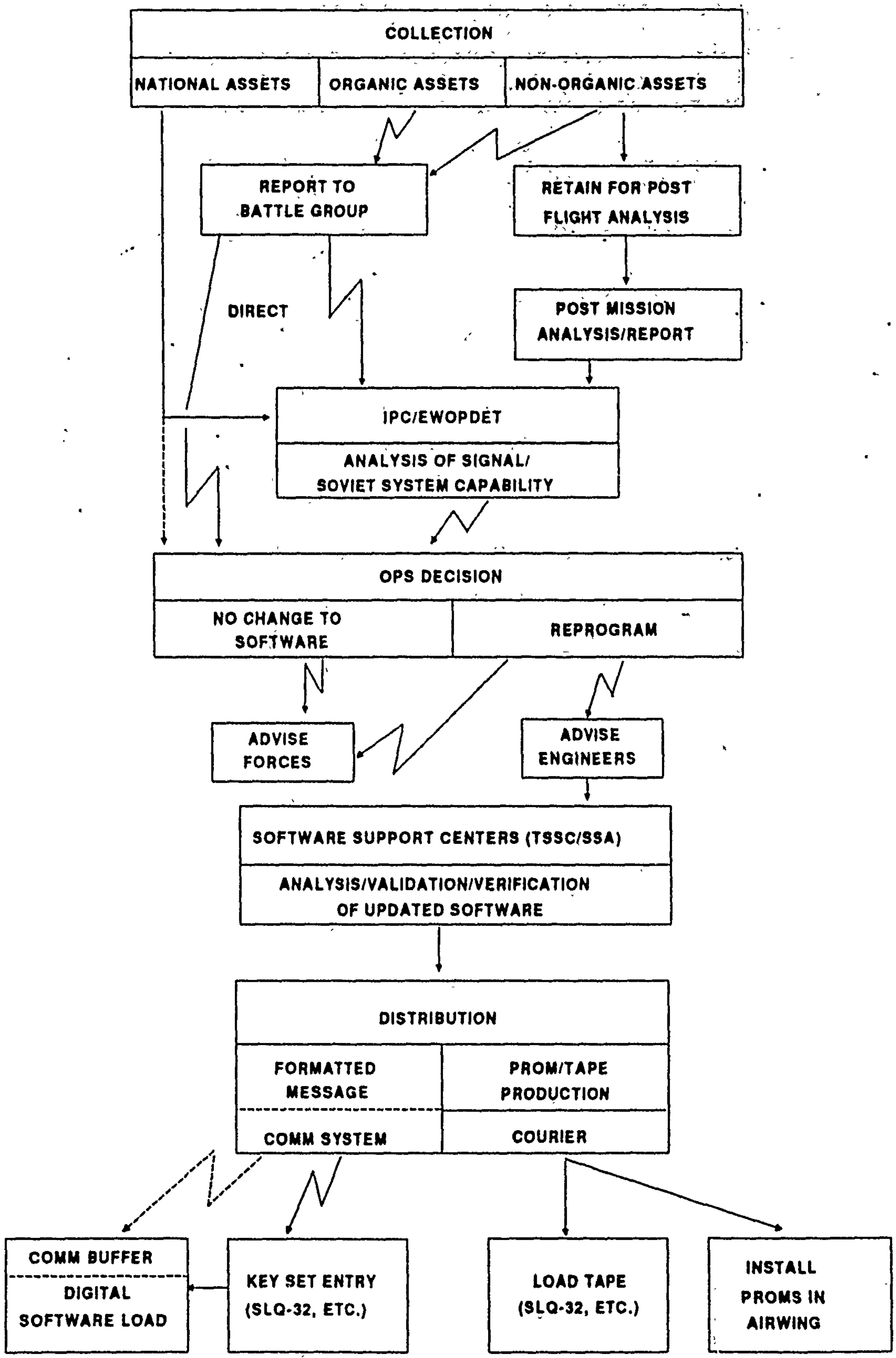

FIGURE 1. RAPID REPROGRAMMING PROCESS (NEAR TERM)

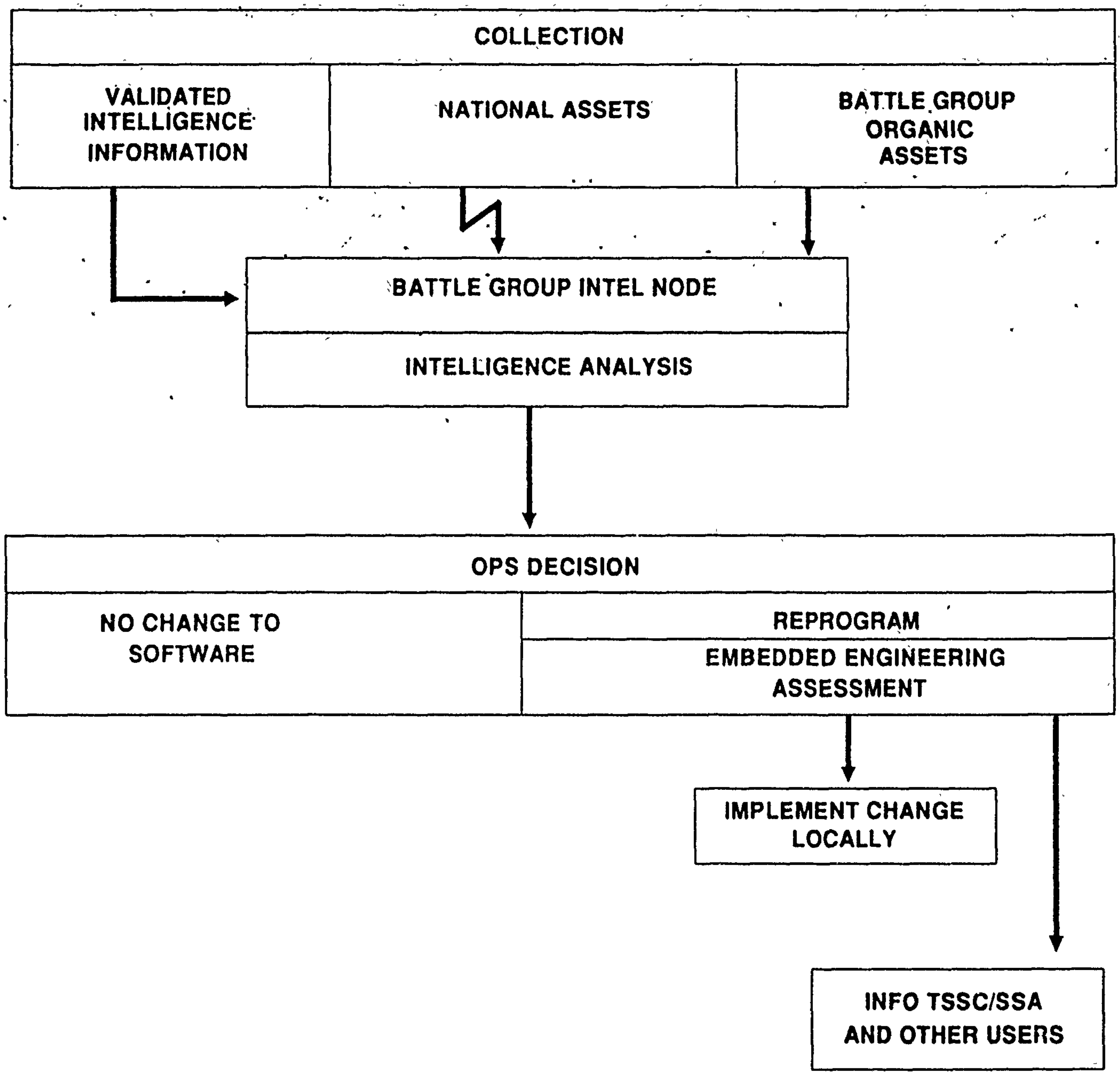

FIGURE 2. RAPID REPROGRAMMING PROCESS (FAR TERM)

EWRL Working Groups

1. EWRL Steering Group - senior management of EWRL Support Program. Consists of Program Sponsor (OP-76), Resource Sponsor (OP-351) Program Manager (PMW-162), System Command representatives, and EWOPFAC OIC.

2. Configuration Control Board (CCB) - review authority for software change proposals. Chaired by SPAWARSYSCOM with representatives from EWOPFAC, EWOPDETLANT/EUR, EWOPDETPAC, NSWC, Dahlgren, PMTC, NWC, NSGA, Charleston and non-voting members as appropriate.

3. Producer's Working Group - reports/recommends changes to CCB based upon analyst/operators input and fleet feedback which may include standardized data field lengths and threat nomenclature; may resolve procedural matters internally. Chaired by EWOPFAC with representatives from EWOPDETLANT/EUR, EWOPDETPAC, NSGA Charleston, TSSCs/SSAs and fleet organizations by invitation. EWOPDETLANT/EUR will represent EWOPDETEUR.

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NAVAL EMITTER REFERENCE FILE (NERF) FEEDBACK REPORT

ORGANIZATION	NERF EDITION (MON/YR)

1. DESCRIBE NERF ADP OPERATING ENVIRONMENT.

2. DESCRIBE ANY PROBLEMS USING NERF, ASSISTANCE NEEDED.

3. DID NERF DATA FIELDS AND ADP MEDIA FIT YOUR REQUIREMENTS.

4. DOES ORGANIZATION NEED NERF DATA BASE DESIGN DOCUMENT (MAY 88).

5. DESCRIBE PERIODICITY USING NERF AND NAVY PROGRAM SUPPORTED.

6. NERF DISTRIBUTION REQUIRED (ANNUAL/SEMIANNUAL/QUARTERLY).

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9. DESCRIPTION OF DIFFICULTY, ACTION TAKEN AND RECOMMENDATION			
10. IMPACT IF NOT CORRECTED			

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5. REPORTED BY: Name of individual who originated Feedback Report.
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9. DESCRIPTION OF DIFFICULTY: Describe the problem, recommendation for improvement, and any action taken.
10. IMPACT IF NOT CORRECTED: If problem not corrected, what impact will this have on performance and identification.
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